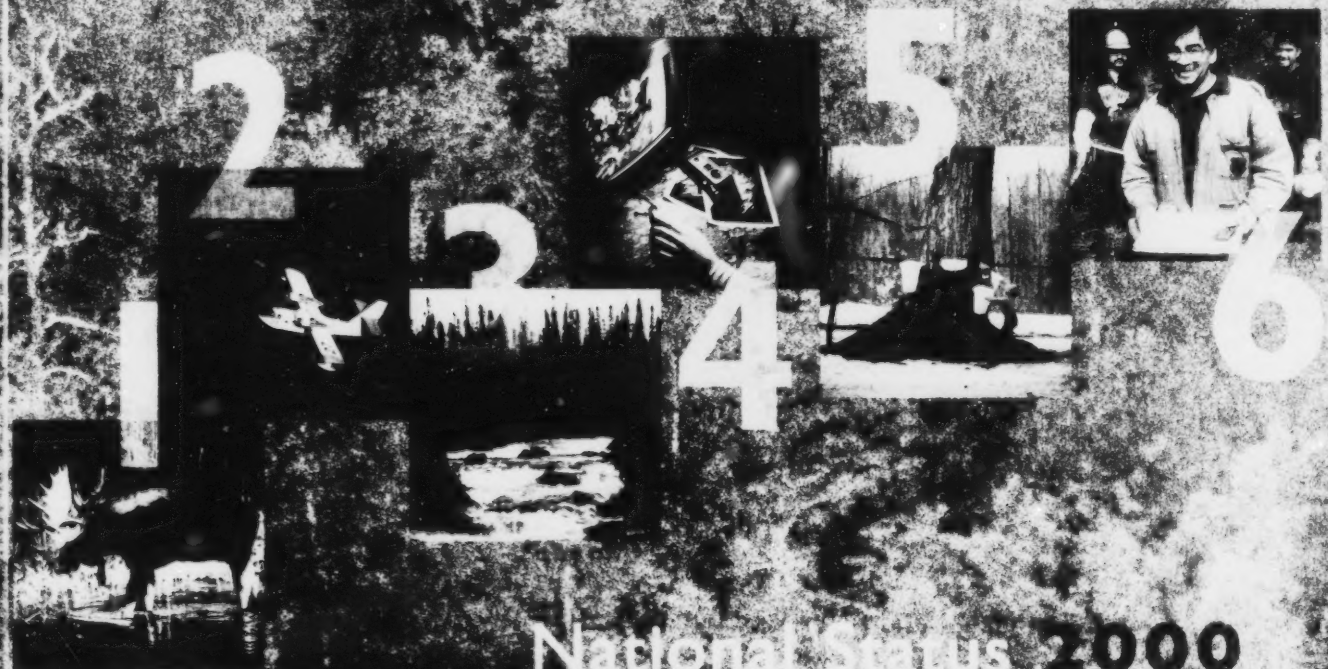
CRITERIA

AND INDICATORS

OF SUSTAINABLE FOREST MANAGEMENT

CANADA



National Status 2000

Canadian Council of Forest Ministers

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CRITERIA AND INDICATORS OF SUSTAINABLE FOREST MANAGEMENT IN CANADA

National Status 2000

Canadian Council of Forest Ministers
Conseil canadien des ministres des forêts

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Key milestones and accomplishments in the development of the CCFM C&I initiative:

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1993 The Canadian Council of Forest Ministers (CCFM) embarks on a process to develop a Canadian set of C&I;

1995 CCFM agrees to a Canadian framework of 6 criteria and 83 indicators described in the publication, *Defining sustainable forest management: A Canadian approach to criteria and indicators*;

1997 CCFM releases *Criteria and indicators of sustainable forest management in Canada: Technical report* describing Canada's capacity to report on the indicators, and the summary report, *Criteria and indicators of sustainable forest management in Canada: Progress to date*;

The CCFM agrees to an implementation plan to report on a core set of indicators to be published in the year 2000 and to review the 83 indicators in the CCFM framework;

1998 The National Forest Strategy commits Canada to producing a C&I report in 2000 and on a regular basis thereafter;

2000 *Criteria and indicators of sustainable forest management in Canada: National status 2000*, reports on 62 indicators in the CCFM framework.

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In 1993, the CCFM formed a C&I Task Force (see inside back cover for current members) and launched a public process to develop a framework of science-based C&I that could be used to define and measure Canada's progress in the sustainable management of forests. These efforts led to the 1995 publication of the C&I framework, *Defining sustainable forest management: A Canadian approach to criteria and indicators*. This report was followed by a capacity report, *Criteria and indicators of sustainable forest management in Canada: Technical report*, in 1997, which outlined the data available for reporting on the framework.

Canada's commitment to sustainable forest management was renewed with the National Forest Strategy 1998-2003 and through the more than 40 signatories to the new Forest Accord. The new Strategy committed to action plans for a C&I report in 2000 and regular reporting thereafter.

Building upon the knowledge gained from the preparation of the capacity report in 1997, the CCFM developed an implementation plan for reporting on a sub-set of indicators in the C&I framework in 2000. The selection of theses indicators was based on the availability of information, on retaining those indicators that are consistent with other national criteria and indicators processes, on combining similar indicators and on eliminating indicators not applicable at the national level. This sub-set of 62 indicators constitutes the structure of this report.

The C&I Framework

The CCFM C&I framework is composed of criteria that define a set of values Canadians want to enhance

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MILESTONES

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The C&I Framework

The CCFM C&I framework is composed of criteria that define a set of values Canadians want to enhance

and sustain, while the indicators identify scientific factors to assess the state of the forests and measure progress over time.

The criteria encompass six areas:

1. Conservation of biological diversity;
2. Maintenance and enhancement of forest ecosystem condition and productivity;
3. Conservation of soil and water resources;
4. Forest ecosystem contributions to global ecological cycles;
5. Multiple benefits to society;
6. Accepting society's responsibility for sustainable development.

The criteria are subdivided into 22 elements and 83 indicators (see tear-out sheet at back).

Together the criteria and indicators characterize the essential components of sustainable forest management and provide a framework for assessing national progress toward this goal. The C&I framework provides a scientific reference point for the development of policies on the conservation, management and sustainable development of forests. The indicators represent a scientific basis for assessing the state of Canada's forests and management practices at the national level. They are not performance standards and are not designed for use at the stand or forest management unit level. An assessment of progress in achieving sustainable development is based on the combination of all the indicators in the framework rather than on the measurement of individual indicators.

Implementation of C&I

Various approaches have been followed to implement C&I at sub-national levels. Several provinces have acknowledged their further commitment to sustainably manage forest resources by adopting their own sets of C&I. Quebec has developed a framework of 60 indicators, based on the CCFM framework, that is expected to be implemented over a three-year period. Ontario has drafted a comprehensive set of indicators for use in evaluating and reporting on forest sustainability. In both of these provinces, the C&I have been integrated into forest legislation and policies. Saskatchewan is currently developing indicators for forest ecosystem health.

Other provinces and territories are incorporating C&I into their forest management planning processes. In Newfoundland and Labrador, the government is drafting a 20-year forestry development plan that will contain specific references to a provincial set of C&I, and is considering having the indicators integrated into legislation. New Brunswick has developed a vision document for its forests that provides a framework for forest management and sets out policy goals and explicit standards and objectives to be used in the development of forest management plans on Crown Timber Licences.

The CCFM C&I framework is also being adapted for implementation under Canada's Model Forest Program. This process involves identification, testing, application and monitoring of indicators at the local (forest management unit) level. Each of the 11 model forests across the country has adopted the definition of sustainable forest management, as set out in the six criteria of the CCFM framework, in order to establish its own suite of local level indicators. Several industries and provincial governments are drawing upon this approach to develop regional or provincial indicators, while others are linking the local level indicators to certification requirements.

In 1996, The Canadian Standards Association developed a standard for a sustainable forest management system. This standard requires that the six criteria be addressed and specifies 21 critical elements based on those in the CCFM C&I framework.

OVERVIEW OF CANADA'S MAJOR FORESTED ECOZONES

Canada is a forest nation. Its forests cover 42% of its land mass and represent 10% of the world's forests and more than 30% of the Boreal Forest. Forests play an important role in the economic, social and spiritual well-being of Canadians.

Canada is in the unique position of having the majority of its forests (94%) under public ownership. The remaining 6% are owned by more than 425 000 private landowners. Most of Canada's timber productive forest is managed under provincial or territorial jurisdiction.

Canada is the largest exporter of forest products world wide. The economic health of the forest sector is important to the continued prosperity of the nation, generating 30% of all manufacturing investment.

Forests provide wilderness areas for the cultural, spiritual and recreational benefit of all Canadians and for visitors to Canada, and support an important and growing recreation and tourism industry.

Canada is host to a diversity of forest ecosystems and tree species. The 1996 National Ecological Framework (tear-out map at back) divides the country into 15 terrestrial ecozones, 53 ecoprovinces, 194 ecoregions and more than 1 000 ecodistricts, (Ecological Stratification Working Group 1996, Marshall and Schut 1999) delineated on the basis of the interactions of geological, landscape, soil, vegetation, climate, wildlife, water and human factors. The majority of Canada's forests lie within the eight ecozones discussed below (Wiken 1986, Wood and Addison 1997, Urquizo et al. 2000).

The **Taiga Plains** ecozone is bordered on the west by the cordillera mountain ranges, to the east by Great Bear Lake and Great Slave Lake, to the north by the Mackenzie Delta and to the south by the closed forests of the Boreal Plains ecozone. Short cool summers and long cold winters result from the influence of arctic air for most of the year.

The ecozone is about 80% forested, but has relatively little standing timber volume per hectare. Taiga is a Russian word that literally means "the land of little sticks" and refers to the northern edge of the boreal coniferous forest. This ecozone is a transition between mixed forest-tundra and dense coniferous forest. The predominant tree is black spruce, which generally occurs as an open, slow-growing species in the ecozone. Along the nutrient-rich alluvial flats of the larger rivers white spruce and balsam poplar grow to sizes comparable with the largest in the boreal forest. The Mackenzie River, Canada's largest river, dominates the ecozone and the Mackenzie Valley forms one of North America's most travelled migratory corridors for waterfowl breeding along the Arctic Coast.

The population of 23 986 (density [persons per square kilometer] 0.04) is approximately 60% Aboriginal. Mining, oil and gas exploration and some forestry and tourism are the main activities in the ecozone.

The **Boreal Cordillera** ecozone, covering sections of northern British Columbia and the southern Yukon, has a Pacific Maritime influence that

moderates temperatures over most of its area. The climate is marked by long, cold winters and short, warm summers.

The ecozone is 61% forested. Vegetative cover ranges from closed to open canopy forest. Tree species include white and black spruces, alpine fir, lodgepole pine, trembling aspen, balsam poplar and white birch. The tree line ranges from 1 500 metres in the southeast to about 1 200 metres in the northwest, where the stands are generally open, and there are almost no lodgepole pine or alpine fir. Shrub birch–willow communities are common in the subalpine forest and extend into the alpine tundra above the tree line. Permanent ice and snow fields occur in the mountains along the western side of the ecozone.

This ecozone is sparsely populated, with the majority of the population of approximately 32 904 (density 0.1) residing in the larger communities of Whitehorse and Dawson. The major economic activity is mining followed by forestry, tourism, and hydroelectric development. Some agriculture is associated with the large watersheds.

The **Boreal Plains**, extending from Peace River, British Columbia, in the northwest to the southeastern corner of Manitoba are part of the Boreal Forest. Unlike the neighbouring Boreal Shield, the Boreal Plains ecozone has few bedrock outcrops, fewer lakes, a higher percentage of non-forest land and some private lands.

Cold winters and moderately warm summers are characteristic of the climate which is strongly influenced by continental climatic conditions. Jack and lodgepole pines, white and black spruces and tamarack are the main coniferous species with mixed stands of aspen and white spruce occurring on nutrient-rich sites. A two-stage silvicultural system, involving harvest of the aspen canopy while protecting the valuable white spruce understory, is followed in these mixedwood stands.

The population of the ecozone is 744 631 (density 1.1). Major land uses in the Boreal Plains include agriculture, forestry, oil and gas exploration, mining, hunting and trapping, outdoor recreation and tourism.

The **Boreal Shield** ecozone stretches from the eastern tip of Newfoundland to the northeastern corner of Alberta. At 195 million hectares, it is the largest ecozone in Canada, encompassing almost 20% of Canada's land mass and accounts for 22% of the country's freshwater surface area.

The headwaters of numerous large drainage basin systems such as the Nelson and Churchill rivers in Manitoba, the St. Lawrence river in Ontario, and the Eastmain, Rupert, Nottaway and Broadback rivers in Quebec are found in this ecozone. The abundance of water attracts hundreds of thousands of migratory birds and provides important habitats for fish and other aquatic organisms.

The ecozone has a strongly continental climate characterized by long cold winters and short warm summers except in the coastal margins where it is moderated by maritime conditions. Vegetation in the Boreal Shield is the result of cool temperatures, a short growing season, frequent forest fires and acidic soils. The ecozone is almost 80% forested and much of it remains in wilderness condition. Closed stands of

conifers, largely white and black spruce, balsam fir and tamarack are characteristic. Toward the south there is a wider distribution of broad-leaved trees such as white birch, trembling aspen and balsam poplar and needle-leaf trees such as white, red and jack pine. Tree growth and timber volume are lower than in most of the other forested ecozones in Canada.

Fire suppression and harvesting have resulted in an increase in the balsam fir content of stands, usually at the expense of white spruce. In the eastern portion of the ecozone, balsam fir is often the dominant species, but the challenge is to protect it from spruce budworm (a native pest that can be destructive during major outbreaks) long enough for the trees to reach rotation age or a size at which they can be harvested. In the central and western portions of the ecozone, balsam fir is an understory component of boreal mixedwood stands, but is not as important a commercial species as in the east. On lowland sites in the Boreal Shield, black spruce occurs in nearly pure stands. Natural regeneration is emphasized in the ecozone, partly to conserve genetic and structural diversity within stands. Fire suppression and harvesting practices throughout the ecozone have also resulted in a shift from conifers to hardwoods, particularly in the boreal mixedwoods and the red pine and white pine stands in the southern part of the ecozone.

With a total population of 2 895 437 (density 1.5), the Boreal Shield is home to roughly 11.5% of Canada's population. Almost 60% of the population lives in urban centres, the largest of which is St. John's, Newfoundland. Many towns have developed around the rich natural resource base. Mining and forestry each account for 5.4% of the total labour force with fisheries and agriculture contributing 2.5% and 2.2% respectively. Other commercial activities include hydro power, water-oriented recreation and tourism and commercial and subsistence hunting, trapping and fishing.

The **Pacific Maritime** ecozone extends in a thin zone along the Pacific Coast. This ecozone has some of the warmest and wettest climatic conditions in Canada. Relative to the rest of the country, there is little variation in mean monthly temperatures.

The ecozone is divided almost evenly between forested and non-forested land. Mountainous topography dominates the landscape, with numerous fiords and glacial valleys, bordered by coastal plains along the Pacific margin. The ecozone is characterized by big trees, steep slopes and old forests with long intervals between disturbances such as fire or windstorms.

Forestry is the principal activity. Forest productivity and the cost of harvesting wood are the highest in the country. The lowlands of the Fraser Valley and the southeastern tip of Vancouver Island possess an expanse of highly productive agricultural soils and urban lands. Fishing, transportation and tourism are other economic activities. The total population of 2 848 289 (density 13.4) is concentrated in Vancouver and the lower mainland and in Victoria.

The **Montane Cordillera** ecozone, nestled between the Pacific Maritime, Boreal Plains and the Boreal Cordillera ecozones, is the most complex of all of the ecozones, with an exceptional diversity of topography and climate. Several mountain ranges run north to south and there are a number of interior plains. It is also home to Canada's only true desert. Depending on elevation and exposure, vegetation ranges from alpine tundra to dense conifer forest that is almost coastal in appearance, to high elevation subalpine fir and Englemann spruce to dry sagebrush and grasslands. The ecozone has more than 11 000 lakes and seven major river systems including the headwaters of the Fraser and Columbia rivers.

The Montane Cordillera is a fire-dominated ecosystem. Approximately 70% of the area is forested. Fire suppression has resulted in the accumulation of too much older age class forest that is becoming more and more prone to catastrophic wildfire. With aggressive fire suppression, insects such as bark beetles are able to have a major impact upon the forest. After the Pacific Maritime, this ecozone has the highest volume of standing timber.

Forestry is an important economic activity, particularly in the northern interior sections. Mining, gas and oil production and tourism are also significant economic activities in the ecozone. A series of national and provincial parks have been established in the Rocky and Columbia mountains for recreational use or to preserve wildlife habitat. Although this ecozone is much less urbanized than the Pacific Maritime ecozone, more than half of its 851 656 (density 1.7) inhabitants live in cities and towns such as Prince George, Kelowna, Kamloops, Penticton and Vernon.

The **Mixedwood Plains** ecozone covers the Great Lakes-St. Lawrence River Valley. The ecozone is the northernmost extension of the deciduous forest biome that extends throughout much of the eastern United States. The climate is marked by hot humid summers and cool winters. Geographic location, waterways and a combination of gentle topography, fertile soils, a warm growing season and abundant rainfall have made this the most densely populated and intensely used area in Canada.

Once heavily forested, the Mixedwood Plains supported a greater diversity of trees and plants than any other part of Canada. It now has less than 20% forest cover, ranging from the mixed deciduous–coniferous stands in the northern portions to the highly diverse deciduous stands of the Carolinian forest in the southwest near Windsor, Ontario. Most of the deciduous forest has been cleared away for farms, orchards, highways and cities. In some areas in extreme southwestern Ontario, forest cover has been reduced to less than 3% of the land base. Over the course of two centuries of settlement and development, a characteristic fragmented landscape mosaic of agriculture, urban development and remnant natural areas has emerged. Pressures on the remaining woodlands are expected to increase as the human population within the ecozone continues to grow.

Spanning the shorelines of three of the Great Lakes, this ecozone includes important aquatic ecosystems, industrial complexes and recreation areas. Manufacturing and services are the prominent economic activities. Approximately 50% of Canada's population, or 14 840 411 people (density 130.2), reside in the ecozone. Almost 85% of the residents live

in urban centres stretching along the Quebec City–Windsor corridor, where two of Canada's largest cities, Montréal and Toronto, are situated.

The **Atlantic Maritime** ecozone covers all of Nova Scotia, New Brunswick, Prince Edward Island and part of Quebec. The Atlantic Ocean creates a cool, moist maritime climate. The ecozone is heavily forested with mixed stands of conifers and deciduous species. There is a long history of European settlement, with most of the native forest being burnt or harvested at least once in the past two centuries. This ecozone has the highest percentage of private woodlots in Canada.

Natural regeneration following harvesting is common in the Atlantic Maritime ecozone. Specialized fill planting or diversity planting may be used to complement natural regeneration where necessary. A two-pass harvesting system has been introduced whereby balsam fir and hardwoods are removed during the first pass. The spruce component, retained for diversity and regeneration, is harvested about twenty years later.

Agriculture, forestry and mining are the major land-based activities, while in coastal communities, fishing has traditionally been the most important source of income. Tourism also contributes to the economy of the ecozone. The majority of the population of 2 549 061 (density 12.6) is found in coastal lowland communities.

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CRITERION 1

CONSERVATION OF BIOLOGICAL DIVERSITY

INTRODUCTION

1.1 Ecosystem Diversity

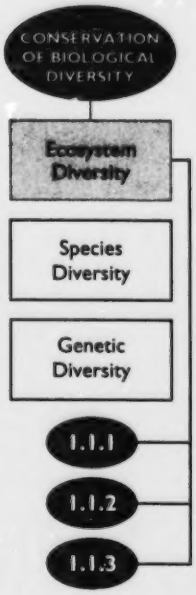
- 1.1.1 Percentage and extent, in area, of forest types relative to historical condition and to total forest area
- 1.1.2 Percentage and extent of area by forest type and age class
- 1.1.3 Area, percentage and representativeness of forest types in protected areas

1.2 Species Diversity

- 1.2.1 Number of known forest-dependent species classified as extinct, threatened, endangered, rare or vulnerable relative to total number of known forest-dependent species
- 1.2.2 Population levels and changes over time of selected species and species guilds
- 1.2.3 Number of known forest-dependent species that occupy only a small portion of their former range

INTRODUCTION

CONSERVATION OF BIOLOGICAL DIVERSITY



Biological diversity, or biodiversity, refers to the variability among living organisms and the ecological complexes of which they are a part. Biodiversity can be measured at the ecosystem, species and genetic levels. Ecosystem diversity describes the variety of ecosystems found in a landscape, while species diversity describes the number and variety of species in those ecosystems. Genetic diversity includes the range of genetic characteristics found within a species and among different species. The conservation of biodiversity ensures that forest ecosystems maintain their integrity and continue to be productive and to adapt to changing conditions.

Forest ecosystems are shaped by dynamic processes. The populations, species, forest types and age classes that comprise Canada's forests are determined through cycles of disturbance and renewal. Maintaining biodiversity entails examining ecosystems at many levels of organization and at different time and spatial scales. It also involves making land-use and resource management decisions that incorporate biodiversity needs, such as limiting the conversion of forests to agricultural and urban lands, creating protected areas, managing the harvest of forest plants and animals, preventing the invasion of foreign insects and diseases, and protecting wildlife habitat through well-planned forest management activities.

The diverse ecosystems of Canada's native forests span a wide range of climates—the lush Carolinian forests of southern Ontario; the sparse strings of trees along arctic rivers; the rainforests of the west coast; and the dry ponderosa pine forests of interior British Columbia. Canada practises natural management of forests, retaining a large component of native species. The forests are largely dominated by coniferous species, but deciduous species are frequent. According to a taxonomic census carried out by the Canadian Museum of Nature, Canada is home to approximately 140 000 species, only half of which have been described (Mosquin et al. 1995). Approximately two thirds of these species, most of which are insects or other arthropods, occur in forest ecosystems.

Canada, along with many other nations, signed the *United Nations Convention on Biological Diversity*. The Convention has three main objectives: the conservation of biological diversity; the sustainable use of its components; and fair and equitable sharing of the benefits that arise out of the use of genetic resources. Provincial, territorial and other governments are collaborating to implement the Canadian component of the convention in their own way.

Element 1.1 *(Ecosystem Diversity)* examines the range and extent of softwood, mixedwood and hardwood forest cover on public and private lands in Canada. Element 1.2 *(Species Diversity)* is concerned with the status of forest-dependent animal and plant species and with determining possible threats to their survival.

ELEMENT 1.1 ECOSYSTEM DIVERSITY

ELEMENT OVERVIEW

An ecosystem consists of the plant, animal and microbial communities in an area interacting as a functional unit with their physical and climatic environment. Ecosystem diversity refers to the variation among ecosystems within a landscape and includes measures that characterize their dimensions, composition and spatial arrangement. Climate, habitat type and disturbance patterns influence species composition within individual forest ecosystems. Each species has particular habitat requirements and

interacts with other species for food, reproduction and other needs. Indirectly, ecosystem diversity ensures the provision of ecological services such as waste assimilation, carbon storage, soil conservation and productivity, nutrient cycling, flood control, water storage and supply, climate stabilization and oxygen supply.

A characterization of the area and extent of the forest land base and its major forest types (Indicator 1.1.1) is the foundation upon which allocation and management of forest lands, and their use and preservation, is based. A diversity of landscapes is essential for maintaining ecological integrity. In addition to a variety of ecosystems, conserving biological diversity includes conservation of forest structure (the vertical layering of trees, shrubs and other plants), and patches (the pattern of different forest ecosystems across the landscape). Information on structure is important for the conservation of diversity at the ecosystem, species and genetic levels because it enables timber harvests to be planned so as to maintain a full range of ecosystem types and successional habitats. Groups of native species tend to be associated with particular successional stages of forest types. Measurement of forest type and age class distribution (Indicators 1.1.1 and 1.1.2) determines the availability of habitat for these species.

Protected areas (Indicator 1.1.3) can serve as ecological benchmarks for comparative research such as assessing the impact of forest management practices on biodiversity. In addition to the ecological benefits of maintaining the ecosystem, species and genetic diversity of a region, protected areas may also provide economic, social, wilderness and other recreational functions and may conserve culturally important heritage sites.

A number of initiatives since 1992 have led to significant progress in the completion of a network of conservation areas representative of the diversity of Canada's forests. The federal, provincial and territorial governments, together with their partners under the *National Forest Strategy*, remain committed to completing the network and to establishing inventories, plans, guidelines and monitoring programs for maintaining it.

TABLE 1.1a Area of Canada's forest by terrestrial ecozone

Ecozone	Total area (thousand ha)	Total forest area* (thousand ha)	% total area	Productive forest on public and private land (thousand ha)	% total forest area	Productive forest on private land (thousand ha)	% total forest area
Arctic Cordillera	25 059	51	0.2	0	0.0	0	0.0
Northern Arctic	151 088	0	0.0	0	0.0	0	0.0
Southern Arctic	83 239	3 235	3.9	9	0.3	0	0.0
Taiga Cordillera	26 484	8 487	32.0	583	6.9	0	0.0
Taiga Plains	64 700	50 020	77.3	17 076	34.1	9	0.0
Taiga Shield	136 640	52 676	38.6	10 215	19.4	2	0.0
Boreal Cordillera	46 460	28 816	62.0	13 914	48.3	3	0.0
Boreal Plains	73 780	49 817	67.5	33 798	67.8	1 906	3.8
Boreal Shield	194 637	151 078	77.6	106 096	70.2	7 633	5.1
Pacific Maritime	21 898	10 057	45.9	8 563	85.1	423	4.2
Montane Cordillera	49 211	34 857	70.8	32 129	92.2	1 348	3.9
Prairies	47 811	2 085	4.4	1 778	85.3	1 093	52.4
Hudson Plains	36 236	6 717	18.5	1 537	22.9	202	3.0
Mixedwood Plains	19 443	3 655	18.8	3 301	90.3	3 121	85.4
Atlantic Maritime	20 375	16 033	78.7	15 571	97.1	8 546	53.3
Canada	**997 061**	**417 584**	**41.9**	**244 570**	**58.6**	**24 286**	**5.8**

**Detectable water bodies and treeless wetlands are excluded.*

Source: Lowe et al. 1996

TABLE 1.1b Distribution of forest cover types in public and private timber productive forests, by ecozone

ECOZONE	FOREST COVER TYPE (%)					
	PUBLIC			PRIVATE		
	Softwood	Mixedwood	Hardwood	Softwood	Mixedwood	Hardwood
Taiga Plains	34.4	53.1	12.5	24.8	39.1	36.1
Boreal Cordillera	76.4	20.2	3.4	34.3	38.5	27.2
Boreal Plains	42.2	22.4	35.4	6.0	15.0	79.1
Boreal Shield	68.7	20.2	11.1	31.6	30.2	38.2
Pacific Maritime	95.3	2.9	1.8	71.1	12.5	16.4
Montane Cordillera	91.2	7.3	1.6	61.0	25.7	13.4
Mixedwood Plains	30.2	28.2	41.6	14.2	27.9	57.9
Atlantic Maritime	50.8	27.6	21.6	35.6	32.2	32.2

Source: Lowe et al. 1996

INDICATOR REPORTS

1.1.1 PERCENTAGE AND EXTENT, IN AREA, OF FOREST TYPES RELATIVE TO HISTORICAL CONDITION AND TO TOTAL FOREST AREA

The data in Table 1.1a and 1.1b are from *Canada's Forest Inventory 1994* (Lowe et al. 1996). The inventory is an aggregation of data from provincial/territorial management inventories and is periodically updated at the national level. Because the management inventories are being continually upgraded, the national inventory is composed of information gathered at different times, and cannot be used to monitor change relative to historic condition.

The total area of Canada is 997 061 thousand hectares. Nearly 42% of this area is covered by forests. The 1996 *National Ecological Framework* (Tear-out map at back) divides Canada into 15 terrestrial ecozones. All except the Northern Arctic ecozone have some forest cover. Eleven of these ecozones have 15% or more forest cover. Nearly 60% of the forest is classified as productive forest land defined as "capable of producing a harvestable volume of timber within a reasonable length of time" (Haddon 1988).

The public forest is owned and managed under either federal, provincial or territorial governments. Private forests comprise only 10% of the timber productive forest land. Differences in management regimes between public and private lands are reflected in the characteristics of the forest ecosystems found on these lands.

Softwoods dominate the forests of the Pacific Maritime and Montane Cordillera ecozones in western Canada. Table 1.1b, which provides data for timber productive forests only, shows that public forests in these ecozones have over 90% softwood cover. Public forests have more than 50% softwood cover in all other ecozones except the Boreal Plains, Taiga Plains and Mixedwood Plains.

The Boreal Plains and Taiga Plains ecozones support a higher percentage of hardwood and mixed hardwood-conifer stands than the Boreal Shield ecozone found immediately to the east. Hardwoods, poplar species in particular, prefer the Boreal Plains and Taiga Plains ecozones where the soils are deeper, less rocky and less acidic, but more productive, than the soils of the Boreal Shield.

The Mixedwood Plains ecozone, located in southern Ontario and Quebec in the Great Lakes and St. Lawrence River basins, has the greatest hardwood dominance in Canada. More than 40% of the forests are dominated by sugar maple and other temperate hardwoods.

In ecozones with significant areas of productive forest land, the proportion of hardwoods is significantly

higher in private forests than public forests (Table 1.1b) because hardwoods often dominate regeneration on recently harvested sites, and harvesting activity is greater on private lands. Private forests are generally found on more productive soils and in warmer areas within an ecozone, two factors that also favour hardwood dominance. The southern portion of the Boreal Plains ecozone includes an area of hardwood (aspen) parkland, transitional to the prairies, which is mostly privately owned. It has a much greater diversity of hardwood species than the "true" boreal forest to the north, as well as a higher proportion of private lands. The following case study from Ontario illustrates the dominance of certain tree species for this area.

Case Study: Forest types on private land in Ontario

Ontario has a total land area of approximately 106.8 million hectares, of which approximately 69.2 million hectares are forested. Ontario's forests include a diverse range of ecosystems and associated wildlife species. Tree species range from boreal species (black spruce and jack pine) in the north to Carolinian species (Kentucky coffee tree and sassafras) in the extreme south.

Three terrestrial ecozones: Hudson Plains, Boreal Shield and Mixedwood Plains (Ecological Stratification Working Group 1996) are found in Ontario. Foresters recognize an additional area in the southern portion of the Boreal Shield known as the Great Lakes-St. Lawrence Forest. A portion of this Ontario ecozone approximates a subdivision of the Boreal Shield referred to as ecoregion 98 (Algonquin-Lake Nipissing). As shown in Figure 1.1a, the forest in this ecoregion has a species composition distinct from that of the Boreal Shield ecozone.

Private forest land is concentrated in the southern, more densely populated portion of the province. The percentage of forest that is privately owned is as follows:

- Hudson Plains – 0.1%
- Boreal Shield – 6.1%
- Algonquin-Lake Nipissing – 37.1%
- Mixedwood Plains – 95.2%

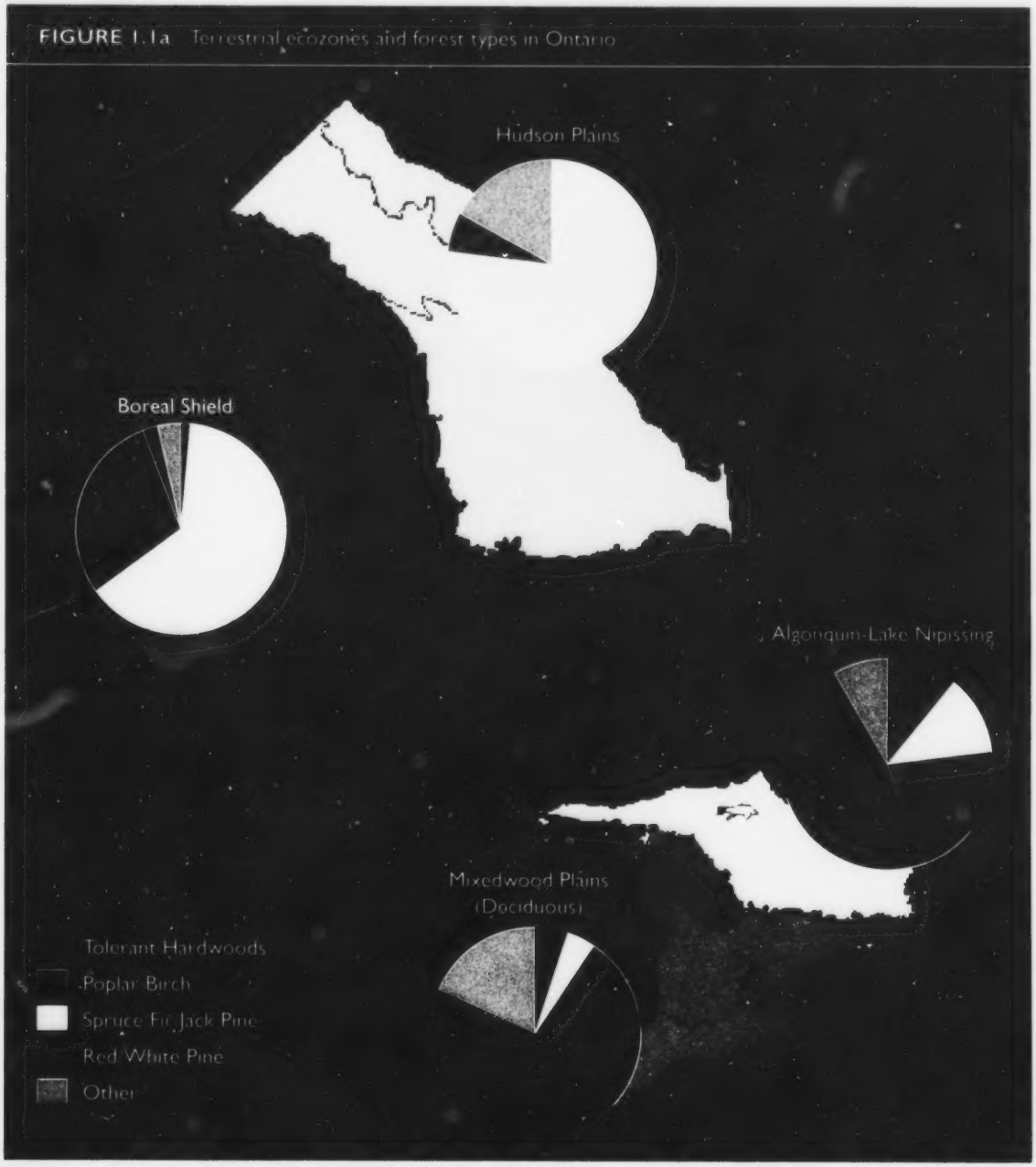
1.1.2 PERCENTAGE AND EXTENT OF AREA BY FOREST TYPE AND AGE CLASS

Canada's boreal forests are primarily composed of even-aged stands. Their composition and age class structure are dynamic, evolving with major disturbances such as fires, insect outbreaks and harvesting. Some species have adapted to a fire-dominated natural disturbance regime. In these ecosystems, fire suppression may serve to increase stand density and shift species compositions to later successional stages. Forest management has the potential to change age class and structural properties of a forested landscape, resulting in changes in biodiversity. Harvesting lowers average forest age, reduces woody debris (snags and fallen logs), and alters the size distribution of forest patches. As a result, species adapted to young successional stages may temporarily increase with the creation of new habitat.

Northern areas are characterized by poorer forest resources with a lower priority for forest management. Most northern inventories do not have age class information and in some cases, age class may not be comparable across inventories. This information is reported as missing (Gray and Power 1997). The data shown in Figure 1.1b has been normalized to consider missing information.

Figure 1.1b expands the information presented in Table 1.1b to illustrate age class information for each of the cover types, in public and private forests, by ecozone. It does not include uneven-aged stands that are being managed through partial harvest treatments. As these treatments are more commonly applied to hardwood stands than conifer, the data probably understate the occurrence of older hardwood forests in Canada.

Canada's hardwood forests have fewer older-aged stands than do softwood forests. Several factors account for this difference: the tendency for hardwoods such as aspen and birch to replace conifers following harvesting in the boreal ecozones; the shorter life-span of most hardwood species; and the higher proportions of hardwoods on more productive sites where harvesting pressure is greater.

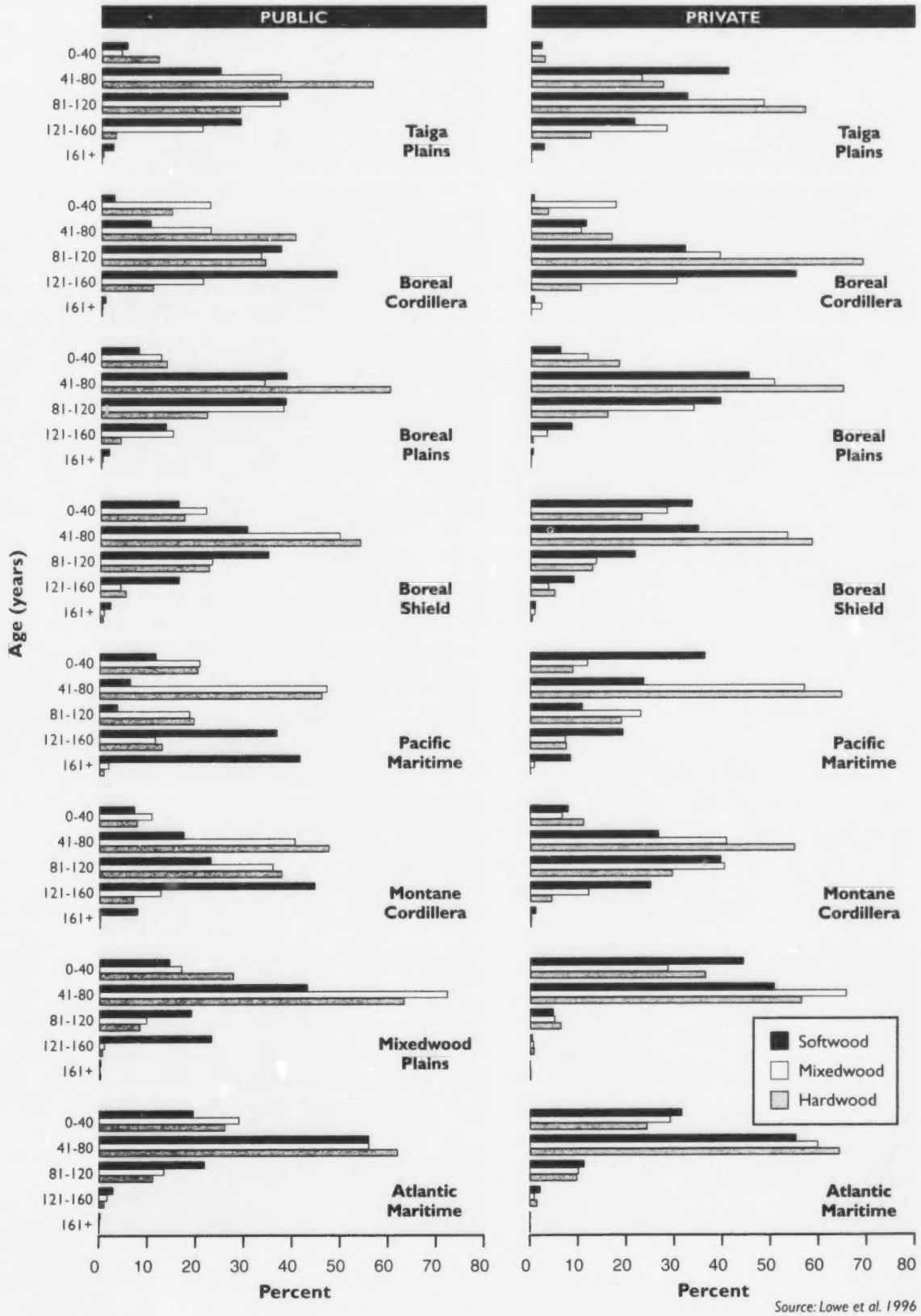


Note: The other species proportions are made up of larch, hemlock, ash and other species. *Source: Ontario Ministry of Natural Resources 1996*

Forests more than 160 years old are primarily found in the Pacific Maritime ecozone of the west coast where major natural disturbances are infrequent. Immediately to the east, the Montane Cordillera ecozone also has a significant but much lower proportion of similar old forests, occurring in certain climactically favourable locations. The remaining ecozones typically have much younger forests, reflecting a higher frequency of insect and fire disturbance and a longer history of forest management.

Figure 1.1b also shows that forests on private lands tend to be much younger than those on public lands. This is true for softwood, mixedwood and hardwood cover types.

FIGURE 1.1b Age class distributions by forest cover type in public and private productive forest land



Source: Lowe et al. 1996

1.1.3 AREA, PERCENTAGE AND REPRESENTATIVENESS OF FOREST TYPES IN PROTECTED AREAS

The World Conservation Union (IUCN) defines a protected area as "an area of land and/or sea especially dedicated to the protection of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means". Six IUCN categories of protected area are designated, depending on their management objectives (see text box p. 9).

Canada has a long tradition of protecting its natural heritage, and is internationally recognized for its many parks. From Canada's first park, established in 1885, the national network of parks has expanded to include 38 National Parks and Reserves, three Marine Conservation Areas and 792 Historic Sites. Together with land that has been withdrawn for future national parks, this protected area covers 29 583 450 hectares. The 48 National Wildlife Areas, covering 489 330 hectares, provide protection for wildlife and their habitats under the *Canada Wildlife Act.*

In addition to National Parks and Reserves, an extensive system of provincial, territorial and municipal parks stretches across the country. Conservation of forest values also occurs outside of formally protected areas. Nineteen percent of productive forest land is classified as being under "policy constraint". This area includes land that will not be harvested due to policy or legislative guidelines: land, for example, that serves as buffers along watercourses or land that is owned by or managed through agreements with conservation agencies. A case study from New Brunswick (Table 1.1c) illustrates the various existing categories that protect the province's natural values.

In the past, decisions taken by governments to establish protected areas were often based on landscape features and natural beauty. In recent years, conservation efforts have been directed toward protecting areas that contain representative examples of Canada's biodiversity. Government policies are collectively supportive of completing a network of protected areas. Most provinces and territories have been involved in extensive consultations to reconcile economic and social interests and have made significant progress toward protecting representative areas.

Canada faces a variety of challenges in meeting its current commitments to establish a network of representative protected areas. For example, hundreds of different categories of protected areas exist. There is no authoritative and comprehensive national mechanism to collect and report on biodiversity data in relation to protected areas and it is not yet possible to distinguish among forest types or between forest and non-forest protected areas. In addition there is the issue of overlapping responsibilities and coordination of efforts among governments.

Using 1995 data from Environment Canada (1997), the previous C&I publication (CCFM 1997) reported that 7.6% of Canada's forest land, or 31.7 million hectares, were found in protected areas (of which over half are strictly protected in IUCN categories I to III). Recent additions that have not yet been compiled nationally have significantly increased the area of protected forest.

The results of a recently published study (World Wildlife Fund 1999) suggest that protected forest areas in Canada may now represent approximately 8.4% of the total forest area. The gap analysis used for this report identified 388 forested natural regions in Canada, of which 32 were described as adequately represented, 75 as moderately represented and a further 122 as partially represented.

New initiatives to legislate or reserve extensive areas for protection categories, which will further increase the area of protected forests and the representation of forest types and natural habitats, have been undertaken by several governments.

Under the *Ontario Forest Accord*, which is an agreement between the Ontario Ministry of Natural Resources and representatives of the forest industry and environmental groups, 378 new protected areas are to be established, totalling 2.4 million hectares. This brings the total protected forest area in Ontario, in IUCN categories I to VI, to 5.1 million hectares. In 1998, Nova Scotia legislated 31 new wilderness areas as reserves, totalling 300 000 hectares. The addition of these areas to the existing provincial and federal parks will raise the total protected area in Nova Scotia to 7.8% of the land base. Pursuant to the 1998 Manitoba–First Nations *Memorandum of Understanding*, Manitoba gave interim protection to 900 000 hectares of forest land. By 1999, Manitoba

TABLE 1.1c Conservation objectives in New Brunswick

Type	Area (ha)	Objective	Ownership
Wetland	20 622	Managed as habitat for aquatic plants, animals and especially migratory birds.	Public (38%) Private (62%)
Ecological reserve	1 212	Reserves, ranging from 50 to 20 ha in size, protect rare and endangered species and unique habitat. Public access is limited and closely supervised.	Public
Conservation area	7 909	Similar to ecological reserves but with hunting and fishing permitted.	Public
Deer wintering areas	268 500	Trees are thinned and planted to maintain healthy winter habitat to be used by deer during periods of deep snow cover.	Public
Mature coniferous forest habitat	172 000	Land management practices require that at least 10% of public coniferous forest be kept in mature or older condition, in patches mostly greater than 500 ha.	Public
Watercourse buffer zone	284 500	Law dictates that the banks of all watercourses are managed for the protection of these waters.	Public (87%) Private (13%)
Migratory bird sanctuary	275	Areas managed as resting areas for migratory birds. Hunting is prohibited and access is limited.	Public
Ramsar site (Site classified as wetland of international importance)	17 484	Conservation and wise use of wetlands.	Public
Nature preserves	317	Managed for nature preservation.	Private
Provincial Park	23 000	Protection of significant natural, cultural and recreational environments, while providing opportunities for visitors to participate in recreational activities.	Public
National Park	45 500	Protection of Canada's natural regions.	Public
Stewardship agreements	900	Protection for rare or unique species or habitat through partnerships with private landowners and conservation groups.	Private
Canadian Heritage Rivers	—	Long-term management and conservation of the natural, cultural, historical and recreational value of outstanding rivers.	Public
Other protected areas	—	Sites under conservation management by municipalities/conservation groups/industry.	Public Private

Source: LaPierre 1997

had protected 5.4 million hectares, encompassing 8.3% of the province. Over the last decade, British Columbia has doubled the area under protection with a current 10.8 million hectares (11.4%) of the province in protected areas.

Since Alberta's Special Places Program was announced in March 1995, 55 sites have been designated, adding nearly 728 000 new hectares to the province's network of protected areas. The program aims to complete a network of protected areas that will preserve representative examples of the province's six natural regions and twenty subregions. During the Alberta Legislative Assembly's 2000 Spring Session, the *Wilderness Areas, Ecological Reserves and Natural Areas Amendment Act* was passed. This creates a "heritage rangeland" class of protected area which will support the completion of the Special Places Program. The results of a public consultation process that concluded in November 1999 are still under consideration to determine what changes will be included in new parks and protected areas legislation which will consolidate, streamline, update and improve Alberta's parks and protected areas legislation, establish a revised system of classes of protected areas, and clarify the purpose and management requirements of each class.

Case Study: Protected areas in New Brunswick

New Brunswick is Canada's most heavily forested province. Eighty-five percent of its 7 108 309 hectares is covered with forest. Approximately one half is publicly owned land. Principal land uses are agriculture, forestry, mining, residential, industrial and institutional. A growing proportion of the province's land is being managed for conservation objectives (Table 1.1c).

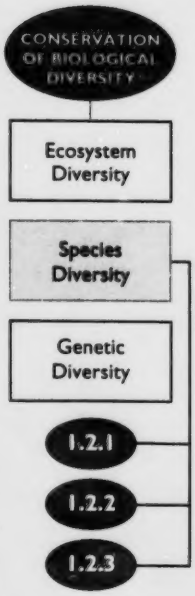
ELEMENT 1.2
SPECIES DIVERSITY

ELEMENT OVERVIEW

Species diversity refers to the number and relative abundance of species found in an area. The impacts of change in ecosystems are expressed through shifts in biodiversity. Loss of species can threaten long-term ecosystem productivity and stability. The number of species at risk in Canada can indicate how well biodiversity resources are being managed (Indicator 1.2.1).

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) determines the national status of wild Canadian species suspected of being at risk (Indicator 1.2.1), based on the best scientific information available. COSEWIC recognizes five classifications of species at risk. Extinct refers to species that no longer exist. Extirpated species are those that no longer exist in the wild in Canada. Species facing imminent extirpation or extinction are considered to be endangered while threatened species are likely to become endangered if limiting factors are not reversed. Vulnerable species are of special concern because of characteristics that make them particularly sensitive to human activities or natural events. Many provinces and territories maintain their own lists of species at risk. To complement COSEWIC's work in listing species, the Recovery of Nationally Endangered Wildlife Committee (RENEW) prepares recovery plans for listed species.

The majority of provinces and territories have endangered species legislation to protect species at risk. In 1996, the federal government signed an *Accord for the Protection of Species at Risk*, which committed all of Canada's jurisdictions to "establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada". Since then, six provinces and territories have introduced new or improved endangered species legislation in addition to the four provinces that already had legislation.



The COSEWIC list (1999) of species, subspecies and individual populations at risk in Canada includes 116 that are forest dependent.

The greatest number of species at risk for specific forest types are found in the coastal forests of British Columbia and in the Carolinian forest remnants of southern Ontario. The Carolinian forest is located in the extreme southwestern region of the Mixedwood Plains ecozone where the Eastern Deciduous Forest of North America has its northernmost limits. It has experienced a loss of approximately 80% of its forest cover since European settlement as a result of agricultural and urban development. Many species that occur here do not exist anywhere else in Canada. More than half of all forest-dependent species at risk are associated with the Carolinian forest. Most of these species are not in danger of extinction on a continental

I Strict nature reserve/wilderness area	Protected area managed mainly for science or wilderness protection
II National park	Protected area managed mainly for ecosystem protection and recreation
III Natural monument	Protected area managed mainly for conservation of specific natural features
IV Habitat/species management area	Protected area managed mainly for conservation through management intervention
V Protected landscape/seascape	Protected area managed mainly for landscape/seascape conservation and recreation
VI Managed resource protection area	Protected area managed for the sustainable use of natural ecosystems

ELEMENT 1.2
SPECIES DIVERSITY

ELEMENT OVERVIEW

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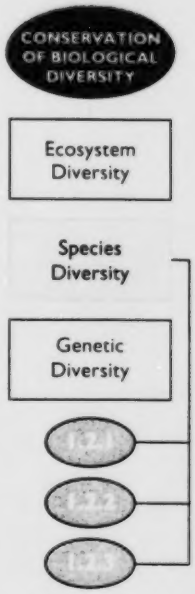

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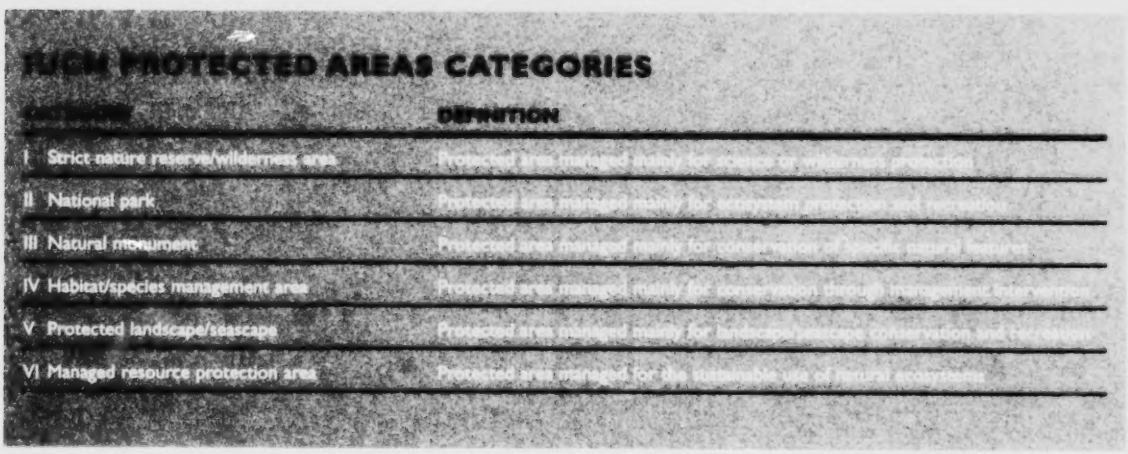

basis. Their status in Canada results mainly from the northern boundary of their ranges extending beyond the Canada–United States border. Threats to species of the temperate rainforests in the Pacific Maritime ecozone include agricultural and urban development and conversion of forests to managed forest stands.

A few forest-dependent animals have been moved to lower risk categories or have been delisted in recent years by COSEWIC. The eastern blue bird, Cooper's hawk and great grey owl have all been removed from the COSEWIC list. Conditions for forest-dependent plants have generally deteriorated, however. Four vascular plants, American ginseng, red mulberry, nodding pogonia and purple twayblade, have changed from threatened to endangered status in 1999.

The presence of healthy populations of native forest-dependent animal species is well accepted as an indicator of the functioning of an ecosystem and the sustainability of forest management activities (Indicator 1.2.2). The previous C&I report (CCFM 1997) proposed a preliminary list of potential indicator species which could be monitored for different ecozones and stand ages within Canada in order to report on ecosystem functioning. Population estimates and trend information are described for selected mammal species from this list.

Species ranges in Canada have changed over time in response to glacial retreats and advances, and over the past 150 years in response to climate fluctuations. Many forest-dependent species currently occupy a small portion of their historic range (Indicator 1.2.3). Although hunting and trapping have contributed to reduced distributions of species, most reductions have resulted from habitat loss.

Indicator species have been used for over 30 years to monitor change in response to pollution. More recently, the monitoring of indicator species has been extended to determine whether forest management practices are having long-term effects on wildlife populations and their habitats (McLaren et al. 1998). The presence of a given species indicates that the particular forest condition needed for that species must be available in sufficient amount to maintain the indicator species as well as populations of all species normally found in association with the indicator.

INDICATOR REPORTS

1.2.1 NUMBER OF KNOWN FOREST-DEPENDENT SPECIES CLASSIFIED AS EXTINCT, THREATENED, ENDANGERED, RARE OR VULNERABLE RELATIVE TO TOTAL NUMBER OF KNOWN FOREST-DEPENDENT SPECIES

It is not yet possible to compare forest-dependent species at risk to total forest-dependent species at the national level because assessments are not complete for all candidate species, particularly butterflies, moths and mollusks. Some provinces have completed this work for certain taxonomic groups. British Columbia and Ontario, for example, have classified most of their forest-dependent species, including fish, and the findings have been incorporated into this report. Quebec released its first report on the status of forest biodiversity in 1996 (Ministère des Ressources naturelles du Québec 1996).

The 1999 COSEWIC status report lists 340 species suspected of being at risk in Canada (COSEWIC 1999). Because the COSEWIC list includes full species, subspecies and individual populations, the use of "species" in this indicator report refers to all of the above categories. Most provinces maintain a list of species at risk that includes species not listed by COSEWIC. This may mean that a species at risk in one province is more common elsewhere in Canada, or that the provincial listing process is more advanced than the national process.

An analysis by the Canadian Forest Service has assigned the 340 COSEWIC-listed species to five categories: 1) forest dependent and forest dwelling, 2) forest dependent but not forest dwelling, 3) forest using but not forest dependent, 4) no significant forest use and 5) forest dependence unknown. This analysis is based on habitat information included in COSEWIC reports, supplemented by a review of relevant literature. Table 1.2a describes Canadian species at risk assigned to categories 1 to 3 of forest dependence. At least 116 (34%) are category 1 and 2 species, dependent on forests for all or part of their food, shelter or reproductive requirements. Assessing the dependence of aquatic species (fish, mollusks) requires specialized

TABLE 1.2a Canadian species at risk according to degree of forest dependence, November 1999

COSEWIC classification	Forest-dependent, forest-dwelling species	Forest-dependent, non-forest-dwelling species	Species that may occur in forests but do not depend on them
Endangered plants (41)* (vascular and non-vascular)	American Ginseng Cucumber Tree Drooping Trillium Heart-leaved Plantain Large Whorled Pogonia Nodding Pogonia Purple Twayblade Red Mulberry Seaside Birds-foot Lotus Seaside Centipede Lichen Small Whorled Pogonia Spotted Wintergreen Wood Poppy (13)	Eastern Prickly Pear Cactus Furbish's Lousewort (2)	Bluehearts Deltoid Balsamroot Englemann's Quillwort Gattinger's Agalinis Hoary Mountain Mint Prairie Lupine Skinner's Agalinis Small White Lady's-slipper Water-plantain Buttercup White Prairie Gentian (10)
Threatened plants (31) (vascular and non-vascular)	American Chestnut Blue Ash Blunt-lobed Woodsia Goldenseal Kentucky Coffee Tree Round-leaved Greenbrier (ON population) van Brunt's Jacob's Ladder White Wood Aster (8)	Apple Moss False Hop Sedge (2)	Anticosti Aster Bird's-foot Violet Colicroot Deerberry Goat's-rue Mosquito Fern White-top Aster Yellow Montane Violet (8)
Vulnerable plants (42) (vascular and non-vascular)	Broad Beech Fern Crooked-stemmed Aster Cryptic Paw Lichen False Rue-anemone Few-flowered Club-rush Green Dragon Hop Tree Oldgrowth Specklebelly Lichen Phantom Orchid Seaside Bone Lichen Shumard Oak Wild Hyacinth (12)	Hill's Pondweed New Jersey Rush (2)	American Columbo Branched Bartonia Bolander's Quillwort Coastal Wood Fern Dense Blazing Star Dwarf Hackberry Long's Bulrush Macoun's Meadowfoam Provancher's Fleabane Swamp Rose Mallow Western Silver-leaf Aster (11)
Endangered mammals (12)	American Marten (NF population) Wolverine (Eastern population) (2)	Vancouver Island Marmot (1)	
Threatened mammals (10)	Pacific Water Shrew Wood Bison Woodland Caribou (Gaspé population) (3)		Townsend's Mole (1)
Vulnerable mammals (27)	Ermine (Queen Charlotte Islands population) Fringed Myotis Bat Gaspé Shrew Grey Fox Grizzly Bear Keen's Long-eared Bat Mountain Beaver Southern Flying Squirrel Spotted Bat Wolverine (Western population) Woodland Caribou (Western population) Woodland Vole (12)	Pallid Bat (1)	Eastern Mole Nuttall's Cottontail (BC population) Ord's Kangaroo Rat Western Harvest Mouse (BC population) (4)
Endangered birds (18)	Acadian Flycatcher Kirtland's Warbler Northern Spotted Owl Prothonotary Warbler (4)	Harlequin Duck (Eastern population) Whooping Crane (2)	Barn Owl (Eastern population) Eskimo Curlew Henslow's Sparrow Loggerhead Shrike (Eastern population) Northern Bobwhite (5)

TABLE 1.2a Canadian species at risk according to degree of forest dependence, November 1999 *(cont'd)*

COSEWIC classification	Forest-dependent, forest-dwelling species	Forest-dependent, non-forest-dwelling species	Species that may occur in forests but do not depend on them
Threatened birds (7)	Hooded Warbler Marbled Murrelet White-headed Woodpecker (3)	Anatum Peregrine Falcon Yellow-breasted Chat (BC population) (2)	Loggerhead Shrike (Prairie population) (1)
Vulnerable birds (22)	Ancient Murrelet Bicknell's Thrush Cerulean Warbler Flammulated Owl Lewis' Woodpecker Louisiana Waterthrush Pacific Great Blue Heron Queen Charlotte Goshawk Red-headed Woodpecker Red-shouldered Hawk (10)	Peale's Peregrine Falcon (1)	Barn Owl (Western population) Ferruginous Hawk Long-billed Curlew Short-eared Owl Yellow-breasted Chat (Eastern population) (5)
Endangered reptiles and amphibians (7)	Blue Racer Snake (1)	Sharp-tailed Snake (1)	Lake Erie Water Snake Northern Cricket Frog Northern Leopard Frog (Southern Mountain population) (3)
Threatened reptiles and amphibians (7)	Black Rat Snake Eastern Fox Snake Eastern Massasauga Rattlesnake Fowler's Toad (4)	Blanding's Turtle (NS population) Queen Snake Spiny Softshell Turtle (3)	
Vulnerable reptiles and amphibians (17)	Coeur d'Alène Salamander Five-lined Skink Mountain Dusky Salamander Northern Red-legged Frog Pacific Giant Salamander Smallmouth Salamander Wood Turtle (7)	Spring Salamander (1)	Eastern Hognose Snake Eastern Yellow-bellied Racer Snake Northern Leopard Frog (Prairie population) Spotted Turtle (4)
Endangered fish (4)	Nooksack Dace Salish Sucker (2)		
Threatened fish (18)	Shorthead Sculpin Morrison Creek Lamprey (2)	Copper Redhorse Lake Simcoe Whitefish (2)	Enos Lake Stickleback Lake Utopia Dwarf Smelt Benthic Paxton Lake Stickleback Limnetic Paxton Lake Stickleback (4)
Vulnerable fish (42)	Redside Dace Speckled Dace Umatilla Dace (3)	Charlotte Unarmoured Stickleback Chestnut Lamprey (2)	Cultus Pygmy Sculpin Giant Stickleback Lake Lamprey White Sturgeon (4)
Endangered lepidopterans (1)			Maritime Ringlet Butterfly (1)
Vulnerable lepidopterans (1)			Monarch Butterfly (1)
Endangered molluscs (4)	Hotwater Physa (1)		
Threatened molluscs (2)		Banff Springs Snail (1)	
Extinct species (12)	Passenger Pigeon Woodland Caribou (Queen Charlotte Islands population) (2)		
Extirpated species (15)	Blue-eyed Mary Karner Blue Butterfly Frosted Elfin Butterfly Island Marble Butterfly (4)		

**Numbers in parentheses indicate the total number of species in each classification.* *Source: COSEWIC Status Reports (COSEWIC 1999)*

TABLE 1.2b Some Canadian species at risk that use savannah habitats

STATUS	PLANTS	ANIMALS
Extirpated		Karner Blue Butterfly
Endangered	Deltoid Balsamroot, Prairie Lupine, Seaside Birds-foot Lotus, Water-plantain Buttercup, White Prairie Gentian	Blue Racer Snake, Loggerhead Shrike, Northern Bobwhite
Threatened	Apple Moss, Bird's-foot Violet, Blue Ash, Colicroot, Deerberry, Goat's-rue, White-top Aster, White Wood Aster, Yellow Montane Violet	Fowler's Toad
Vulnerable	Coastal Wood Fern, Dense Blazing Star, Hop Tree, Western Silver-leaf Aster	Eastern Hognose Snake, Eastern Yellow-bellied Racer Snake, Ord's Kangaroo Rat, Spotted Turtle

Source: COSEWIC Status Reports (COSEWIC 1999)

approaches, and most have been placed in the "unknown" category.

The largest concentrations of forest-dependent species at risk are found in the coastal forests of British Columbia (Pacific Maritime ecozone) and in the Carolinian forest remnants of southern Ontario (Mixedwood Plains ecozone). Canada's vast Boreal Forest contains a much smaller number of species at risk, but several animal species—grizzly bear, woodland caribou, wolverine, Newfoundland pine marten, wood bison—pose particular challenges for public agencies and industries involved in management activities. These animals are often intolerant of high levels of human intrusion, may have complex habitat requirements, and need large areas of older forest.

COSEWIC has downlisted two forest-dependent animal species from endangered to threatened status in recent years (wood bison, peregrine falcon). Three others have been removed from the list (eastern bluebird, Cooper's hawk, great grey owl) as a result of improvements in their condition or better information about their populations. However, four species have been classified in more severe categories. The Newfoundland population of the pine marten and the prothonotary warbler are now considered to be endangered, Fowler's toad is listed as threatened, and the mountain beaver has moved into the vulnerable category.

Conditions for forest-dependent plants at risk has not improved in recent years. No forest-dependent plants have yet been downlisted by COSEWIC, and four (American ginseng, red mulberry, nodding pogonia, and purple twayblade) were uplisted from threatened to endangered status in 1999. The latter three are all Carolinian forest species, facing threats from habitat loss and alien invasive plants. American ginseng, whose range extends into the Great Lakes-St. Lawrence forest of Quebec and Ontario, is endangered primarily because of over harvesting of the plant.

The list of species that use forests but do not depend on them includes a number of savannah, or open woodland species (Table 1.2b). Other savannah species are included as forest-dependent and forest-dwelling, and the distinction between the two is somewhat artificial. Whether or not the presence of trees is essential for survival of these species, the savannah communities in which they occur (including Garry oak woodlands in British Columbia and black oak woodlands in southern Ontario) are among the rarest in Canada. Savannahs require periodic ground fires to

limit invasion of native shrubs and alien plant species, but they are often found in developed areas where the use of prescribed fire as a management tool poses particular challenges. The rarity of these habitats means that extirpation is a risk for some species. The Karner blue butterfly is a fire-dependent oak savannah species that formerly occurred in southern Ontario but has not been sighted in the province since 1991.

1.2.2 POPULATION LEVELS AND CHANGES OVER TIME OF SELECTED SPECIES AND SPECIES GUILDS

The previous C&I report (CCFM 1997) suggested that a pool of species for three forest stages be chosen and monitored as indicators of the functioning of forest ecosystems in different ecozones. While consensus has yet to be reached on a national list of forest indicator species, provincial agencies have been actively involved in identifying species that are useful for indicating changes in habitats over time and specific features of forests such as structure and age class. Several of the 30 proposed mammal indicator species were included in a status assessment prepared for the Canadian Forest Service, the Canadian Pulp and Paper Association and the Biodiversity Convention Office (Alvo 1998). Table 1.2c summarizes results for the species assessed in Alvo (1998).

Grizzly bear, woodland caribou, and wapiti (elk) have been extirpated from eastern portions of their original ranges. Wolf, black bear, fisher, lynx and marten have all been extirpated from Prince Edward Island, illustrating a trend of species loss observed on small islands around the world. Moose and snowshoe hare were intentionally introduced and grew rapidly in numbers on insular Newfoundland.

Four of the mammal species in Table 1.2c have been examined by COSEWIC. Black bear was reviewed in 1999 and judged to be not at risk. Grizzly (or brown) bear was designated not at risk in 1979 and became vulnerable in 1991. These adjustments reflected the sensitivity of the species to environmental changes and hunting pressure. The Newfoundland population of the American (or pine) marten was first listed as not at risk in 1979, was reclassified as threatened in 1986, and subsequently became endangered in 1996. Woodland caribou (the non-migratory caribou) is native to all Canadian provinces and territories except Prince Edward Island. It has steadily retreated in the face of human development in the eastern and southern portions of its original range. A small population on the Gaspé Peninsula of Quebec is considered to be threatened, and the population from Ontario westward is vulnerable. The Labrador-Ungava (Newfoundland and Labrador and Quebec) and Newfoundland populations were both examined in 1984 and found to be not at risk.

Information on the 32 bird species suggested as indicators (CCFM 1997) is presented in Table 1.2d. Of these, 16 have been reviewed one or more times by COSEWIC, and 13 have been designated as vulnerable, threatened, or endangered. For several of the species not reviewed by COSEWIC, the Canadian Wildlife Service provides 30-year population trends based on breeding bird survey data (Hyslop and Kennedy 1996). The pileated woodpecker showed a statistically significant increase between 1966 and 1996, while the boreal chickadee and gray-cheeked thrush declined in numbers. Ruffed grouse declined significantly in British Columbia and Nova Scotia, but showed no significant trend nationally. In interpreting these results, it is important to recognize the limitations of breeding bird survey data. Sampling is done by volunteers who drive along roads, stop at intervals, and record species by their songs. As a result, samples are concentrated in southern Canada where volunteers are most available. Data are lacking for more remote areas (including much of the boreal forest), while species that are naturally rare or are at risk are not sampled frequently enough to assess trends.

1.2.3 NUMBER OF KNOWN FOREST-DEPENDENT SPECIES THAT OCCUPY ONLY A SMALL PORTION OF THEIR FORMER RANGE

Indicator 1.2.3 can be interpreted in two different ways: the current range of a species may be significantly smaller than its original range, or a species may now be found in only a small percentage of habitats formerly occupied within its historic range. The former interpretation would more likely be applied to mammals, and the latter to plants. *Defining sustainable forest management: A Canadian approach to criteria and indicators,* (CCFM 1995), which outlined

TABLE 1.2c Population estimates (thousands) and trends, by province/territory, for mammals proposed as indicator species

Species	Ecozones	Age	YK	NT	BC	AB	SK	MB	ON	QC	NB	NS	PE	NF***
Black Bear	MC	Y	(10)*	(5)	(140)	28.3**	(24)	(29)	75-100	60	(12)	7-8	0	6-10
			(S)	(S)	(S)	S	(S)	(S-I)	S-I	D?	(S-I)	S	X 1894	S
Grizzly Bear	MC, BP	P	(5)	(4-5)	(10-13)	(1)	0	0	0	0	0	0	0	0
			(S)	(S)	(D)	(I?)	n/o	n/o	n/o	n/o	n/o	n/o		
Fisher	GL-SL	P	(R)	(5)	(1-1.5)	(9)	(7.5)	(10)	(18.5)	(13.5)	(1)	1-3	0	0
			?	?	(D?)	(I)	(S-I?)	(S)	I	(S-I)	(S)	D	X 1890	n/o
Lynx	BP, BS	Y	(7-55)	(2-16)	(2-80)	(6-60)	(6-46)	(5-75)	(15-114)	(20-147)	(0.7-5)	<1	0	(6-43)
	MC, AM	Y	(S?)	(S?)	(S)	(S?)	(S)	S	S	(S)	?	D	X 1800	(I)
Marten	MC, BP	M	(60)	(178)	(124)	(35)	(51)	(80)	(130)	(160)	(3)	<1	0	0.3
	BS, AM	M	(I)	(D?)	(D)	(I)	(S?)	(S-I)	S	(S)	(S)	D	X 1879	D
	GL-SL	Y												
Moose	MC, BP	Y	(63)	(137)	(170)	72.3	(40)	(32)	120	70	(23)	4.8-6	0	115
	BS, GL-SL	Y	(S)	?	(S-D)	S-D	(D)	S	S	I	(I)	S-D	X?	N 1878
Mule Deer	MC	Y	(0.75)	0	(345)	17	(50)	(0.4)	0	0	0	0	0	0
			(I)	n/o	S-D	S	(S)	(S)	n/o	n/o	n/o	n/o	n/o	n/o
Wapiti (Elk)	BP	Y, P	(.09)	?	43	13.6	(12)	(9)	0.12	0	0	0	0	0
			(?)	?	S-D	I	(S)	(I)	Re 1932	X	n/o	n/o	n/o	n/o
White-tailed Deer	GL-SL, AM	Y	(R)	(R)	64	43.2	(350)	(120)	350	(300)	(69)	67	0	0
	C	Y, P	(I)	(I)	S-D	I	(S)	(I)	S	(I)	I	S	n/o	n/o
Woodland Caribou	MC	P, M	(32)	(13)	16.5	(5)	(6-9)	(2-18)	20	7-8	0	0	0	95
	BP, BS	P	(I)	?	S-D	(S-D)	(D)	(S-D)	S-D	S	X 1927	X 1925	X 1765	I

Ecozones
MC: Montane Cordillera
BP: Boreal Plains
BS: Boreal Shield
GL-SL: Great Lakes - St. Lawrence
C: Carolinian (Mixedwood Plains)
AM: Atlantic Maritime

Forest Age Class
Y: Young (shrub, sapling)
P: Pole (pole, small tree)
M: Mature and old

Values
A: Abundant
C: Common
S: Stable
I: Increasing
D: Decreasing
X: Extirpated
Re: Reintroduced after extirpation
R: Rare
N: New introduction
n/o: Never occurred
?: Uncertain

**Values with parentheses are from Alvo (1998).*
***Values without parentheses are from provincial agencies.*
****Newfoundland data do not include Labrador.*

Source: Alvo 1998, Provincial/Territorial agencies, McLaren et al. 1997

TABLE 1.2d Status of bird species

FOREST AGE	SPECIES	CANADA TREND, 1966-1996	AREAS OF CONCERN	COSEWIC ACTION
Young[a]	Lewis' Woodpecker	No data	BC	Listed in 1999 - vulnerable
	Golden-crowned Sparrow	No data		N/A[d]
	Ruffed Grouse	- 1.6 %	BC, NS	N/A
	Hairy Woodpecker	+ 1.5 %		N/A
	Hooded Warbler	No data	ON	Listed in 1994 - threatened
Pole	Queen Charlotte Goshawk	No data	BC	Listed in 1995 - vulnerable
	Peale's Peregrine Falcon	No data	BC	Listed in 1978 - vulnerable
	Flammulated Owl	No data	BC	Listed in 1988 - vulnerable
	Mountain Chickadee	- 1.1 %		N/A
	Boreal Chickadee	- 9.7 %[c]	NB, ON, QC,	N/A
	Red Crossbill	- 0.5 %	NF	Under review
	Varied Thrush	+ 1.4 %		N/A
	Barred Owl	- 2.8 %		N/A
	Cooper's Hawk	+ 6.0 %		Delisted in 1996
	Ovenbird	+ 0.0 %		N/A
	Red-shouldered Hawk	-13.1 %	ON,QC,	Listed in 1996 - vulnerable
	Pileated Woodpecker	+ 1.7 %[c]		N/A
	Red-bellied Woodpecker	No data		N/A
	Cerulean Warbler	No data	ON,QC	Listed in 1993 - vulnerable
	Acadian Flycatcher	No data	ON	Listed in 1994 - endangered
	Bicknell's Thrush[b]	No data	NB, NS,QC	Listed in 1999 - vulnerable
Mature	Marbled Murrelet	No data	BC	Listed in 1990 - threatened
	Williamson's Sapsucker	No data		N/A
	White-headed Woodpecker	No data	BC	Listed in 1992 - threatened
	Black-backed Woodpecker	- 1.0 %		N/A
	Three-toed Woodpecker	No data		N/A
	Northern Spotted Owl	No data	BC	Listed in 1986 - endangered
	Hammond's Flycatcher	+ 0.4 %		N/A
	Boreal Owl	No data		Not at risk 1995
	Gray-cheeked Thrush	- 8.9 %[c]	Eastern Canada	N/A
	Eastern Screech-Owl	No data		Not at risk 1986
	Prothonotary Warbler	No data	ON	Uplisted in 1996 - endangered

[a] *Young: shrub, sapling; Pole: small tree; Mature: mature and old.*
[b] *Bicknell's Thrush, formerly considered a subspecies of the Gray-cheeked Thrush, was given full species status in 1995.*
[c] *Trend is statistically significant at the 5% probability level.*
[d] *N/A: No action.*

Source: Hyslop and Kennedy 1996

the framework, does not offer guidance on which interpretation to use. The Montréal Process *Criteria and indicators for the conservation and sustainable management of temperate and boreal forests* includes the same indicator (1.3b), however, and defines it in terms of changes in total range: species that are "dependent on forest types that have been significantly cleared for other purposes" (Montréal Process Working Group in press).

There is no database describing historic and current ranges of species in Canada. Many forest-dependent species occupy only small portions of their historic range. Habitat loss, hunting and trapping, and the introduction of alien species may all contribute to range reductions. Table 1.2e lists species not reviewed by COSEWIC that have been affected primarily by habitat loss, either through clearing of forest lands for agriculture and settlement or by reductions in the amount of forests in the older age classes.

While the original Carolinian forest of southwestern Ontario has experienced a high degree of land conversion for agriculture and urban development, the remaining forest is fragmented and much of it has been repeatedly harvested and lacks the structural features (e.g., woody debris) of mature forests. This has resulted in significant range contractions for all forest-dependent plant species and a number of amphibian and reptile species. The Jefferson salamander now only

TABLE 1.2e Forest-dependent species, by ecozone, that occupy a small portion of their former range (excluding species listed by COSEWIC)

ECOZONE	ANIMALS	PLANTS
Pacific Maritime	Black-tailed Deer, Roosevelt Elk, Townsend's Chipmunk, Trowbridge's Shrew, Sitka Mouse, Pacific Jumping Mouse, Shrew-mole, Townsend's Big-eared Bat, Yuma Myotis Bat, Silver-haired Bat, Clouded Salamander, Varied Thrush, Vaux's Swift	Garry Oak, Yellow-cedar
Montane Cordillera	Rocky Mountain Elk, Fisher, Silver-haired Bat, Yuma Myotis Bat, Townsend's Big-eared Bat, Gopher Snake, Tailed Frog, Varied Thrush, Three Toed Woodpecker, Williamson's Sapsucker, Vaux's Swift, Mountain Chickadee	Ponderosa Pine
Great Lakes / St. Lawrence*	Canada Lynx, Wapiti, River Otter, Silver-haired Bat, Small-footed Bat, Brown Snake, Pickerel Frog, Bald Eagle, Golden Eagle, Peregine Falcon, Cooper's Hawk, Great Grey Owl, Barred Owl, Spruce Grouse, Black-backed Woodpecker	White Pine, Red Pine, Eastern Hemlock, White Spruce, Red Spruce, Wild Leek, Autumn Coral-root
Carolinian**	Bobcat, Fisher, Marten, River Otter, Wild Turkey, Screech Owl	All forest-dependent species
Boreal Shield	Silver-haired Bat, Barred Owl, Boreal Owl, Black-backed Woodpecker, Three-toed Woodpecker, Grey-cheeked Thrush, Red Crossbill	White Pine, Black Spruce, White Spruce
Boreal Plains	Silver-haired Bat, Barred Owl, Boreal Owl, Black-backed Woodpecker, Three-toed Woodpecker, Varied Thrush	Green Ash, White Spruce
Atlantic Maritime	Fisher, Lynx, Marten, Barred Owl, Black-backed Woodpecker, Three-toed Woodpecker	White Pine, Red Pine, Red Spruce, Eastern Hemlock

**The Great Lakes-St. Lawrence forest, which includes the northern portion of the Mixedwood Plains ecozone and the southern portion of the Boreal Shield ecozone in extreme southeastern Manitoba, Ontario and Quebec, has its own characteristic group of species* (see p. 5).

***The Carolinian forest, which is part of the Mixedwood Plains ecozone in extreme southwestern Ontario, has a unique and characteristic group of species.*

Source: CCFM 1997

occurs in a few locations in the "Golden Horseshoe" around the western end of Lake Ontario, a highly urbanized area. The wood turtle, which formerly occurred throughout southwestern Ontario, is now limited to a few locations further north, such as Algonquin Park. The black rat snake has also disappeared from southwestern Ontario, but persists to the east in the Rideau Lakes area. The timber rattlesnake was formerly found along the Niagara Escarpment, but has retreated to the south and is now likely extirpated from Canada, although it may still occur in the Niagara Gorge.

While forests in eastern Canada still occupy well over half their original area, the ranges of many mammal species have shrunk in response to regional habitat loss, hunting and trapping, and frequent human disturbance. The gray wolf, woodland caribou, and wolverine have been extripated from southern Ontario, Quebec, and most eastern provinces (Indicator 1.2.2). The fisher, lynx, marten and moose now occur only on a small portion of their former range in Nova Scotia. Prince Edward Island has experienced the greatest degree of forest clearing of any Canadian province (just over 50%). European settlement occurred around 1700; fisher, lynx, marten, wolf, black bear, caribou and possibly moose were all extirpated before 1900.

There are fewer documented examples of major declines in species ranges in western Canada. The grizzly bear once roamed widely throughout the grasslands and aspen parklands in the southern Prairie provinces, but Prairie populations were extirpated in the late 1800s, and the species' range has been pushed to the west and north. The woodland caribou has disappeared from southern portions of its range in western Canada, and from some mountainous areas in British Columbia. The range of wood bison has contracted significantly. The wood bison is listed by COSEWIC (1999) as threatened while the grizzly bear and western population of woodland caribou are vulnerable.

It should be noted that a "range contraction" definition for this indicator is problematic for some groups—particularly plants and birds. Most individual populations of American ginseng have been lost,

primarily because of over harvesting of the plant roots for their alleged medicinal properties. The remaining populations are widely scattered throughout their original range in Ontario and Quebec. Similarly, many great blue heron rookeries in British Columbia have disappeared because of human disturbance and habitat loss, but the species can still be seen occasionally over most of its original range in the province.

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CRITERION 2

MAINTENANCE AND ENHANCEMENT OF FOREST ECOSYSTEM CONDITION AND PRODUCTIVITY

INTRODUCTION

2.1 Incidence of Disturbance and Stress

- 2.1.1 Area and severity of insect attack
- 2.1.3 Area and severity of fire damage
- 2.1.4 Rates of pollutant deposition
- 2.1.5 Ozone concentrations in forested regions
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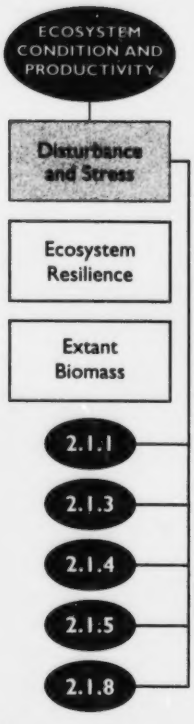
2.3 Extant Biomass

- 2.3.1 Mean annual increment by forest type and age class

INTRODUCTION

MAINTENANCE AND ENHANCEMENT OF FOREST ECOSYSTEM CONDITION AND PRODUCTIVITY



Forest condition is a measure of relative freedom from stress and the relative level of physical/biological energy within a forest ecosystem. Together, forest health and vitality provide an indication of ecosystem condition.

Productivity refers to the rate of production of organic matter within forest ecosystems. Forest productivity results from interactions between biological components (fauna and flora) and abiotic factors such as soil, water, and climate. Sustainable productivity is dependent upon the ability of forest ecosystems to recover from or adapt to disturbances, whether they be natural or human-induced. A healthy and diverse ecosystem is better able to respond to and recover from changes in its environment.

Forest productivity gives rise to a supply of products and services. It can be measured by evaluating the magnitude and impact of various disturbances and determining the forest's ability to sustain itself through various renewal processes such as natural regeneration or management activities. While most disturbance and stress events are fundamental to the recovery and maintenance of forested ecosystems, others may actually impede resilience, alter ecosystem patterns and processes, or affect forest health. Measuring disturbance and stress caused by abiotic and biotic factors provides a basis for improved decision making in managing forests as a renewable resource.

Element 2.1 *(Incidence of Disturbance and Stress)* examines the frequency and severity of major biotic (insects, disease, direct human impact) and abiotic (fire, pollution, temperature) stressors affecting forest ecosystems. Element 2.2 *(Ecosystem Resilience)* attempts to measure the ability of forest ecosystems to recover from stress through an examination of regeneration after harvesting. Finally, Element 2.3 *(Extant Biomass)* provides some understanding of forest ecosystem conditions in Canada by measuring forest biomass productivity and accumulation.

ELEMENT 2.1 INCIDENCE OF DISTURBANCE AND STRESS

ELEMENT OVERVIEW

Ecosystems are constantly changing. Many of these changes are adaptations to disturbance. Disturbances generally cause ecosystems to revert to earlier successional stages or divert to new successional patterns. The ability of forest ecosystems to adapt to the various stresses placed upon them is fundamental to their continued health and vitality and, therefore, productivity. Disturbances may be part of natural ecological cycles or the result of human activities. Natural disturbance is fundamental to the functioning of forest ecosystem processes. Some forests, such as the Boreal, actually depend on these disturbances for their renewal. Human-induced stress and disturbance include introduced (alien) insects, diseases, plants and wildlife, fire suppression, air pollution (e.g., acid rain, smog, toxic chemicals) and land-use practices. Some of these factors may be linked. Fire, for example, is commonly correlated with drought, although other disturbances that promote ignition conditions, such as insects, may also be involved. Together, these stressors form a dynamic complex that may have cumulative impacts, both positive and negative, on forest

conditions over time. Understanding the impact of disturbance regimes on ecosystem processes, at the appropriate spatial and temporal scales, is fundamental to sustainable forest management.

The ability to differentiate between changes in forest ecosystems that are caused by human interference and those caused by natural ecological variability is key to the maintenance and enhancement of desirable forest ecosystem condition and productivity. Tracking the extent and severity of the indicators that characterize this element provides baseline information from which to build an understanding of the year-to-year variation. As our knowledge base expands, the relative influence of human-induced stressors on ecological cycles will be determined.

Although capable of causing extensive timber loss, native insects (Indicator 2.1.1) are an intrinsic component of forest ecosystems, contributing to nutrient cycling and pollination. Along with other natural influences such as fire, they are the drivers of diversity, structure and function in Canada's forests. Losses due to insects and diseases in Canada have been estimated to be equivalent to one third of the annual harvest (Hall and Moody 1994). The spruce budworm and forest tent caterpillar are the dominant insects damaging conifer and broadleaved trees, respectively. The cyclical nature of native populations of forest insects is demonstrated through examples of the area defoliated by these insects over time.

Forest fire (Indicator 2.1.3) has been an integral part of Canada's landscapes for millennia. It has traditionally been considered to be a disturbance, and is probably most widely known and studied in this role. Fire regimes are cyclical and are influenced by several interrelated factors, including climate, vegetation type, ignition sources and insects. Fire affects the structure, composition and functions of ecosystems. Wildland fire threatens forest communities and consumes nearly as much wood as is harvested. Fire management accounts for a significant part of the cost of forest management in Canada. Fire management policies strive to balance suppression with allowing fire to maintain its natural role in managing the landscape.

Fire activity (number of fires and area burned) in Canada over a 25-year period is described in this report. Over the period 1974 to 1998, the number of fires shows no notable trend. The lowest number of fires and the lowest levels for area burned since 1974 were recorded in 1997. However, the most recent 10-year average area burned showed a significant increase due to three extreme years.

Many pollutants affect forest ecosystems. Of these, acidic deposition, ozone, nitrates and heavy metals are the best known. While the effects of pollution damage have been duplicated under laboratory conditions, the mechanism of cause and effect under ambient levels of pollution is difficult to demonstrate. Pollutants (Indicator 2.1.4) travel globally via the atmosphere, impacting on forest ecosystems through dry and wet deposition pathways. Dry deposition is difficult and expensive to measure and is usually calculated from available air concentrations. Wet deposition includes precipitation in the form of rain, snow and fog.

Two of the most common types of air pollutants in Canada's forest ecosystems are sulphur dioxide (SO_2) and nitrogen oxides (NO_x), along with their oxidation products, sulphuric acids and nitric acids, respectively. There is increasing evidence linking the long-term effects of deposition of these acids to the disruption of biogeochemical processes and the decline of annual accumulation of biomass in the forest. Acidic deposition is a continuing concern for the health of sensitive forest ecosystems, particularly in south-eastern Canada. A new long-term goal to not exceed critical loads for acidic deposition has been set to protect forest ecosystems.

Tropospheric or ground-level ozone (Indicator 2.1.5) is produced in the Earth's lower atmosphere from photochemical reactions involving nitrogen oxides (NOx) and volatile organic compounds (VOC) in the presence of sunlight. Ozone builds up in the lower atmosphere, especially on hot days in cities, and drifts into the surrounding areas. It is a regional-scale pollutant subject to long-range transport. Ozone may adversely affect the metabolic systems of plants and become toxic to trees. Decreased photosynthesis, premature defoliation and loss of plant productivity may result from plant exposure to ozone exceeding two to three times background levels over a number of growing seasons. Ecosystem structure and function may also be altered, depending on the sensitivities of various species. Although time series analysis has identified a declining trend in daily maximum ozone concentrations in Canada, three areas have been identified where the national objectives for hourly

ground level ozone are exceeded. These areas are: the southern Maritimes, the Quebec-Windsor corridor and the lower Fraser Valley in southern British Columbia.

Climate, particularly temperature (Indicator 2.1.8), is a major factor affecting Canada's forests. The range of tree species present, the growth rate, and the productivity of the forest are all influenced by temperature, particularly the quantity of heat received during the growing season. Temperature also plays direct and indirect roles in natural disturbances such as fire, disease, and insect outbreaks. As a result, changes or increased variation in temperature can affect the sustainability of forests. Predictions for the effects of global climate change on forest ecosystems (IPCC 1998) include increased growth and range extension of some forests, but declining health in others in response to increased biotic and abiotic stresses. Observations across Canada over the past 45 years suggest that annual temperatures have increased in the west and north, while little change is evident in the east.

Because of incomplete data and insufficient spatial and temporal coverage, interpolation techniques are required to estimate climate in most forested areas, and results must therefore be interpreted with caution. The implications for climate change on the sustainability of Canada's forest remain uncertain.

INDICATOR REPORTS

2.1.1 AREA AND SEVERITY OF INSECT ATTACK

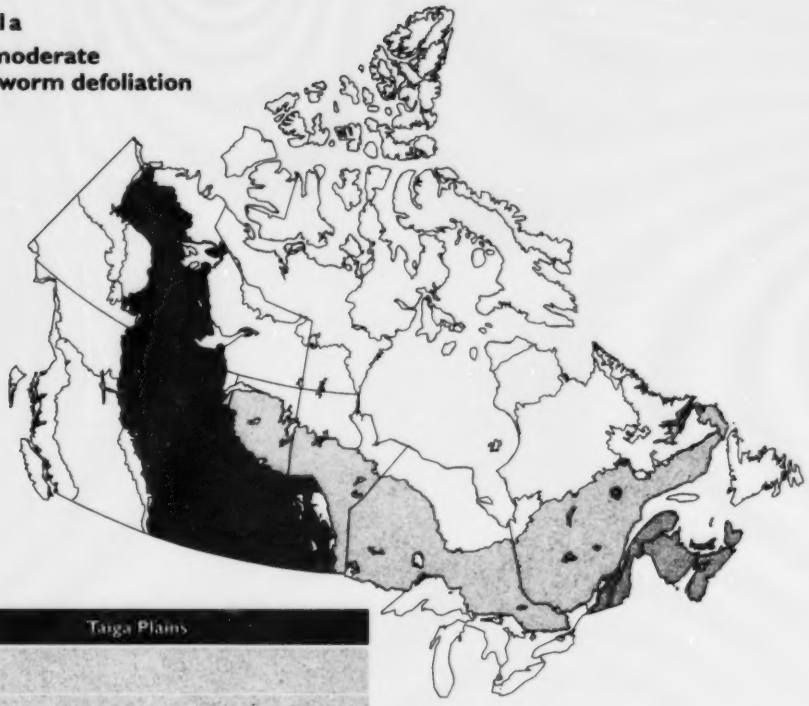
Several native North American insect species— spruce budworm, forest tent caterpillar, hemlock looper and jack pine budworm—annually defoliate areas of Canada's forest (Natural Resources Canada 1999). The Canadian Forest Service and the provinces and territories collect and compile aerial survey data on national insect defoliation. Annual regional and provincial coverages of insect defoliation are combined to produce a national overview of defoliation for each insect by year. Only moderate (defined as 30 to 69% defoliation) and severe damage (defined as 70% defoliation or greater) categories are illustrated in Figures 2.1a, 2.1b and 2.1c. Although every effort has been made to ensure that the figures accurately represent actual forest conditions, the data must be treated with caution as varying standards of data collection and compilation exist across the nation. In addition, some non-forested areas such as roads, cultivated land, small lakes and burned areas may be included in the areas reported.

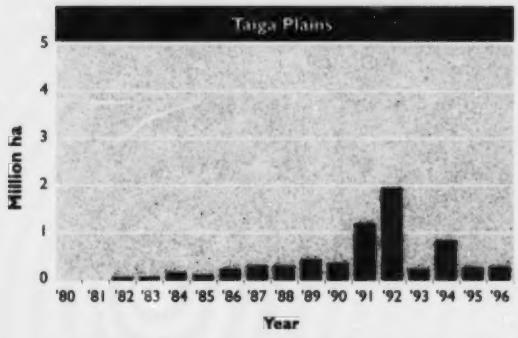
The spruce budworm *(Choristoneura fumiferana)* is considered to be the most destructive pest of fir and spruce forests in eastern Canada. It occurs to varying degrees within several ecozones, but particularly in the Boreal Shield and Atlantic Maritime ecozones (Figure 2.1a). The spruce budworm is reported to attack 25 tree species, including fir, spruce, pine, hemlock, larch and juniper. Growth of balsam fir declines once 30% of the foliage is destroyed. Mortality results after four to five years of moderate to severe defoliation (Natural Resources Canada 1999). Large outbreaks of spruce budworm defoliation follow fluctuations in the insect life cycle. Changes in the composition of the forest associated with fire suppression and harvesting are possible factors influencing the frequency and duration of the attacks (Blais 1983). At its peak in 1975, the spruce budworm defoliated 54 million hectares at moderate to severe levels. There has been a decline in total annual area defoliated from 28 million hectares in 1980 to 1.8 million hectares in 1996.

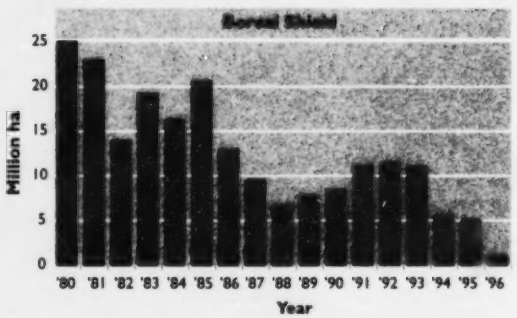
The forest tent caterpillar *(Malacosoma disstria)*, a defoliator of hardwood species, is widely distributed across Canada (Figure 2.1b).The tree species of choice for this pest is the trembling aspen. To a lesser degree, it attacks other poplars, sugar maple and oak. Although the forest tent caterpillar defoliates trees over large areas and may cause extensive growth losses, it generally does not result in mortality or have a long-term impact on forest growth unless prolonged severe defoliation or repeated defoliation accompanied by severe drought occurs. Between 1980 and 1996, there were two cycles of elevated population numbers and a shift in distribution of defoliation from the Boreal Plains to the Boreal Shield.

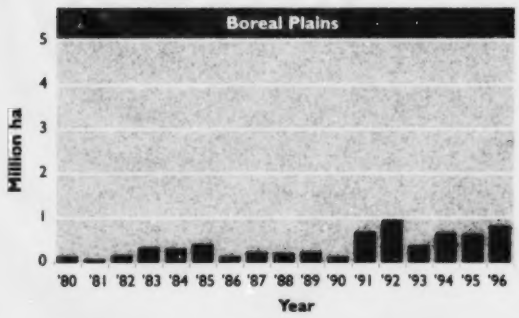
Figure 2.1c describes the frequency and extent of forest tent caterpillar outbreaks in British Columbia, spanning more than 50 years. The cyclical nature of infestation levels has been attributed to land-use changes, fire suppression and the availability of host species. The higher numbers in recent years may reflect more dedicated monitoring efforts.

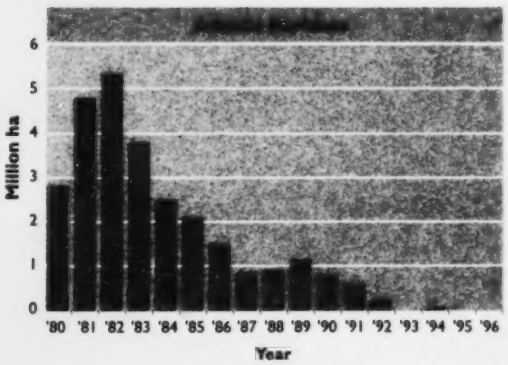
FIGURE 2.1a
Severe to moderate spruce budworm defoliation

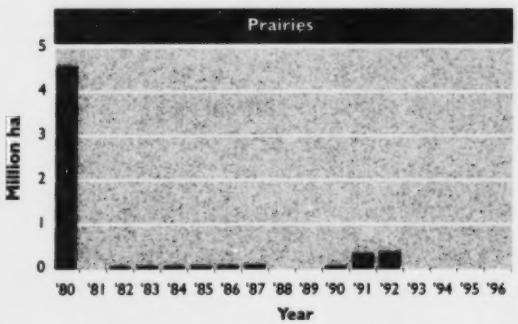








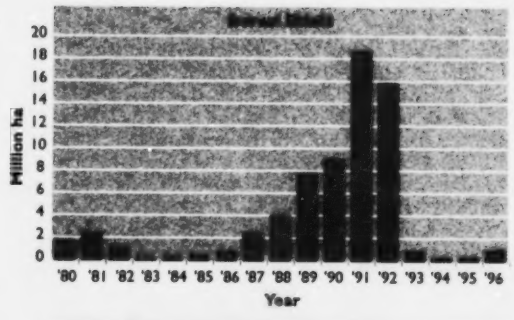


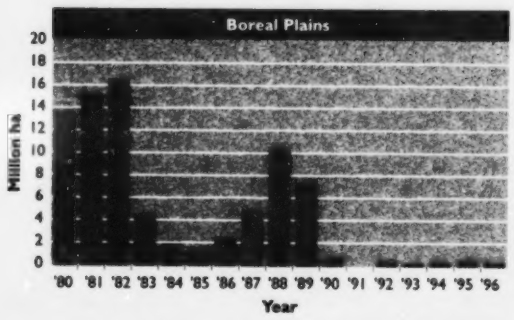


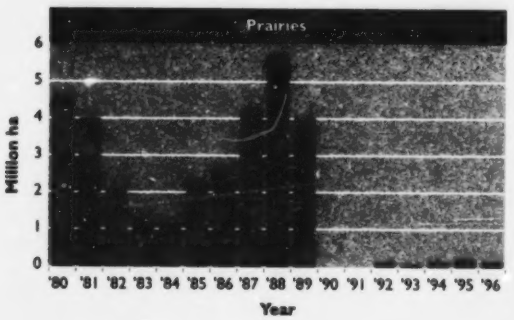
Source: Simpson and Coy 1999

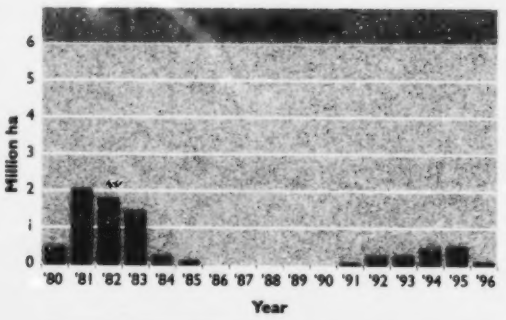
FIGURE 2.1b

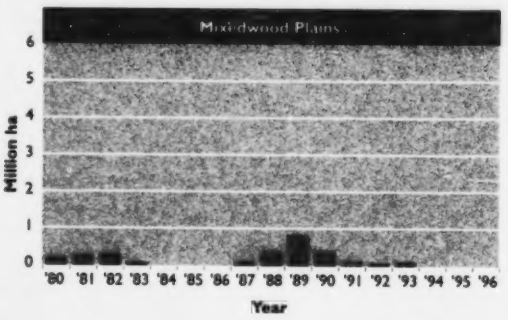
Severe to moderate forest tent caterpillar defoliation







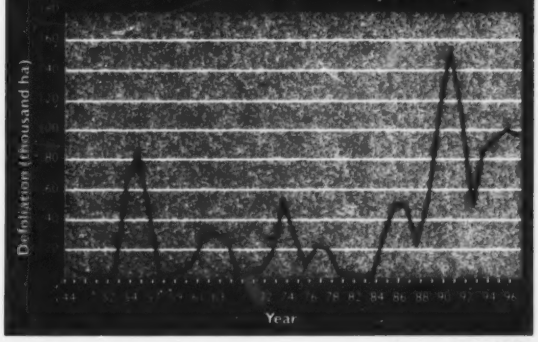




Source: Simpson and Coy 1999

Outbreaks of specific insect species have impacts on the economies of certain regions. The mountain pine beetle, which attacks lodgepole pine mainly within the Montane Cordillera ecozone, provides an example. Not a true defoliator, the mountain pine beetle is the most prevalent species of bark beetle. It attacks the tree through its vascular system (van Sickle 1995). Under normal conditions, these beetles are beneficial in that they help forest regeneration by weakening older trees. However, when beetles reproduce faster than their natural predators, serious damage to large tracts of healthy forest can result. Mountain pine beetle infestations can be devastating as tree mortality can occur within one or two years of infestation. Eggs laid by the females develop into larvae that feed on the inner bark. In 1998, the mountain pine beetle infested more than 31 million cubic metres of standing timber spread over 125 000 hectares. This recent outbreak was attributed to milder weather which allowed about 85% of beetle larvae to survive successfully the winter months (usually only 15% of the larvae successfully over-winter) (British Columbia Ministry of Forests 1998).

FIGURE 2.1c Forest tent caterpillar defoliation in British Columbia, 1944-1996



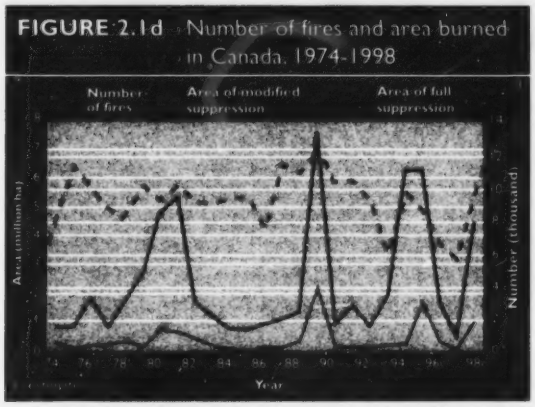
Source: Allen 1998

2.1.3 AREA AND SEVERITY OF FIRE DAMAGE

On average, 91.5% of all fires in Canada burn less than 10 hectares; these fires account for 0.4% of the total area burned. Conversely, the 1.4% of all fires that exceed 1 000 hectares account for 93.1% of the total area burned. Fifty-eight percent of all fires in Canada are started as a result of human carelessness, but these fires burn only 15% of the total area burned. Lightning, on the other hand, starts 42% of all fires and accounts for 85% of the total area burned.

Fire activity over the past 25 years is shown in Figure 2.1d. Due to considerable interannual variability, 10-year averages are used to estimate long-term trends. From 1988 to 1998, an average of 8 823 fires burned 3.2 million hectares annually—0.73% of the total forest land in Canada. The number of fires per year over that period ranged from 6 002 to 12 185, while area burned ranged from 0.6 to 7.5 million hectares. The area burned in 1997 amounted to 0.6 million hectares, the lowest level since 1974. The number of fires shows no notable trend over the past 25 years, although an increase in the frequency of severe fire seasons has increased the 10-year average area burned significantly, from 2.1 to 3.2 million hectares.

FIGURE 2.1d Number of fires and area burned in Canada, 1974-1998



Sources: Natural Resources Canada—Canadian Forest Service 1998, Lowe et al. 1996

Wildland fire performs many valuable ecological services in Canada's forests. Several species are adapted to and may even require fire for reproduction. Other species, however, are very averse to fire and may disappear entirely from an area if fire becomes too frequent or severe. It is therefore important to track not only the national area burned, but also the regional breakdown of fire activity. Furthermore, while fire suppression may allow an increase in the mean stand age in an area, it may also allow greater fuel accumulation, resulting in more severe fires in the future. For this reason, minimizing fire is not necessarily desirable. In fact, long-term forest sustainability requires recognizing the role of fire and the range of natural variability of fire activity.

Fire regimes are cyclical and are influenced by the interactions between climate, vegetation type, ignition sources, etc. Every area has a fire regime which can be partially characterized by the fire-return interval

(average time between fires in the same area). Table 2.1a. shows statistics for large fires for all ecozones except agricultural and arctic regions. Estimated fire-return intervals range from 100 to 10 000 years. Canada's forests will continue to be linked to wild land fire as they have been since the last ice age.

TABLE 2.1a Estimated large-fire return intervals for Canadian ecozones

Interval (years)	Ecozone
10 000	Pacific and Atlantic Maritimes, Mixedwood Plains
5 000	Taiga Cordillera
2 500	Montane Cordillera
1 000	Prairies
500	Boreal Cordillera, Hudson Plains
250	Taiga & Boreal Plains, Taiga & Boreal Shields (part)
100	Boreal Shield (part)

Source: Simard 1997

A significant effect of forest fires is the loss of wood fibre (Figure 2.1e). In the past decade, fires have burned an average of 1.1 million hectares of timber productive land each year—20% more area than is harvested. However, half of the burned area is in immature forests and 20% of the wood lost to fire is salvaged. The result is an average loss of about 130 million cubic metres of wood, equal to 76% of the volume of wood actually harvested and representing an economic loss of just under $2 billion per year. Three extreme years in the past decade have resulted in notably higher wood losses than in the previous 15 years

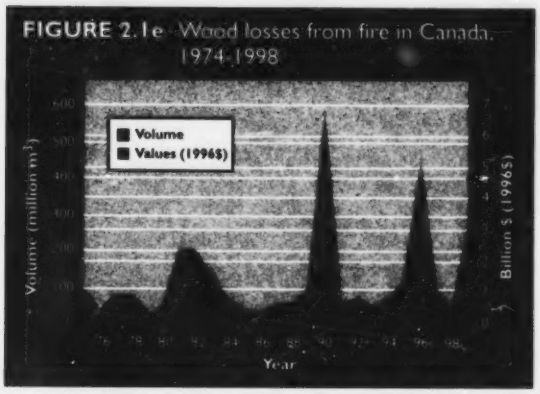


FIGURE 2.1e Wood losses from fire in Canada, 1974-1998

Sources: Natural Resources Canada—Canadian Forest Service 1998, Lowe et al. 1996

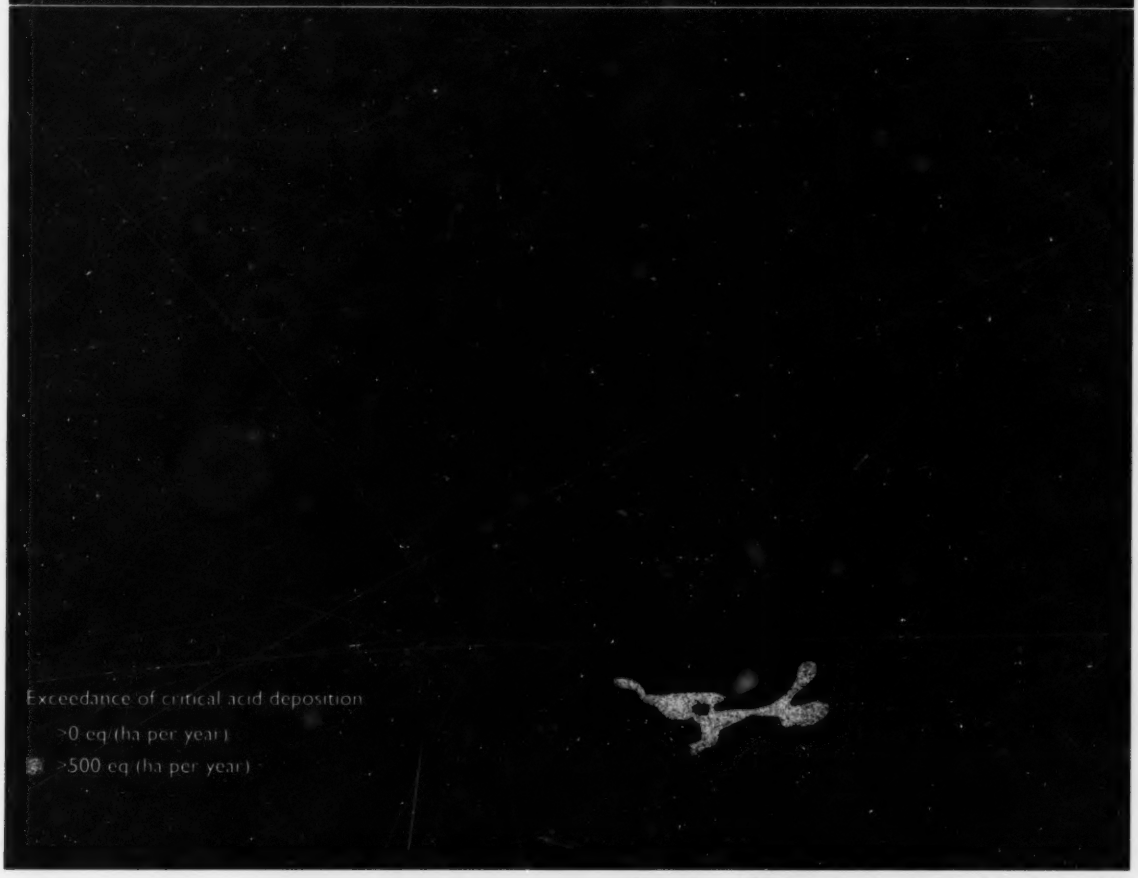
2.1.4 RATES OF POLLUTANT DEPOSITION

A continuing concern for the health of sensitive forest ecosystems, particularly in southeastern Canada, is acidic deposition. Well-established acid rain programs have set a target of 20 kg/ha/yr of wet sulphate deposition, based on the sensitivity of water bodies. The area in eastern Canada receiving more than the target objective of wet sulphate deposition shrank by 46% from the early 1980s to the early 1990s. Model predictions indicate that by 2010, all of Canada will receive less than the target (Acidifying Emissions Task Force 1997). In contrast, there has been little change in NO_3 wet deposition over the same period. Although the deposition of wet sulphate has been reduced to meet the target of 20 kg/ha/yr, there remains concern about the adverse effects of ambient acidic deposition on forest ecosystems. The federal, provincial and territorial Ministers of Environment and Energy signed the *Canada-Wide Acid Rain Strategy* in October 1998. This strategy replaces the old target with the long-term goal of remaining below critical loads.

"Critical load" is defined as the highest deposition of acidifying compounds that will not cause chemical changes leading to long-term harmful effects on the overall structure or function of an ecosystem. Critical loads of acid deposition have been developed for certain Canadian forest soils (Arp et al. 1996). They reflect the inherent capacity of soils to buffer incoming acidity. When combined amounts of sulphur and nitrogen deposition are below these loads, forest ecosystems are buffered against adverse effects. If critical loads are exceeded for long periods, however, essential nutrients for tree growth and vigour are leached from the soil. Continued loss of soil nutrients leads to a decline in forest productivity.

An analysis of data from the Acid Rain National Early Warning System (ARNEWS), for plots monitored by the Canadian Forest Service, indicates that critical loads are consistently exceeded in portions of the eastern Boreal Shield, Atlantic Maritime and Mixedwood Plains ecozones (Hall et al. 1998). Preliminary studies indicate that forest sites with 500 equivalents/(hectare per year) exceedance (Figure 2.1f) suffer an annual productivity loss of 10% (Moayeri and Arp 1997). In addition, the effects of runoff from acidic forest soils can negatively impact populations of aquatic organisms, particularly fish, in these areas (Jeffries 1997).

FIGURE 2.1f Levels of acid deposition exceeding critical loads



Source: Natural Resources Canada—Canadian Forest Service 1999

A forest mapping program under the auspices of the Eastern Premiers/New England Governors Secretariat is currently under consideration for Quebec, the Atlantic provinces, and New England. The intent is to develop, by 2002, estimates of critical loads of acid deposition for all forest ecosystems within these regions.

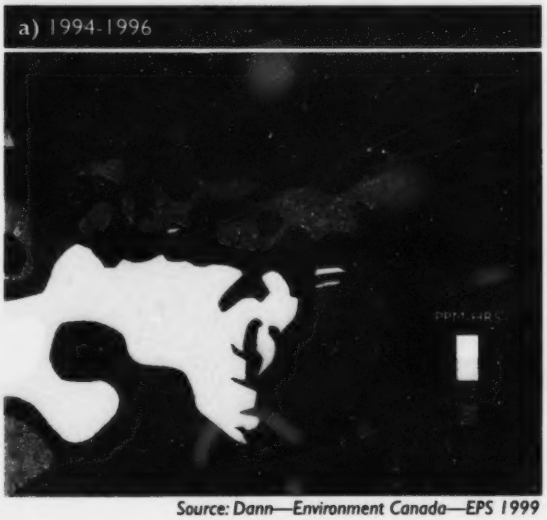
2.1.5 OZONE CONCENTRATIONS IN FORESTED REGIONS

Ground-level or tropospheric ozone may adversely affect the metabolic systems of plants and become toxic to trees. Ozone exposures can be especially damaging under conditions of high humidity and high soil moisture.

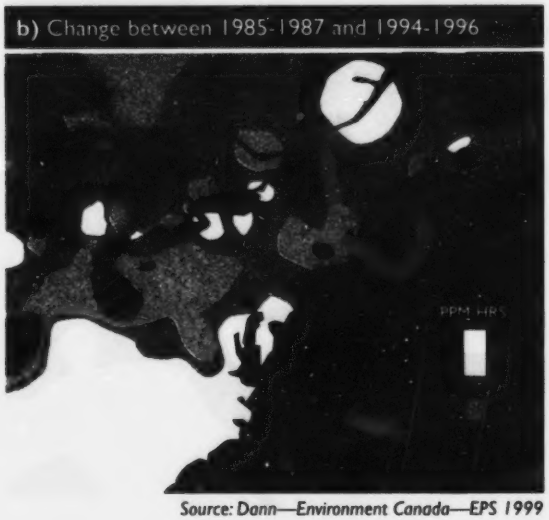
Tropospheric ozone levels are determined through a series of atmospheric models that can predict levels of ozone several hundred metres above the forest canopy. The Canadian Forest Service has been monitoring canopy exposure to ozone using a passive ozone monitor placed in the canopy of trees in selected forest health monitoring plots (Cox and Malcolm 1999). Ozone measures obtained from these simple monitoring devices are then related to aspects of forest health monitored in the same plots and used to validate atmospheric models. In addition, forest canopy ozone exposure values can indicate if a forest area is depleting ozone (taking up ozone) or is aiding its production by providing volatile organic carbon (VOC) which catalyses the production of ozone in polluted air masses.

During July and August (months associated with high ozone events) passive ozone monitoring of forested areas has been carried out for selected sites across the country since 1996. Average hourly means (ppm) of each year monitored will serve to identify forest sites that are chronically exposed to ozone deposition and those that may be at risk.

FIGURE 2.1g SUM06 ozone ppm-hrs for (a) three-year average for 1994-1996 and (b) percent change between 1985 and 1987



Source: Dann—Environment Canada—EPS 1999



Source: Dann—Environment Canada—EPS 1999

SUM 06 is the maximum seasonal sum of hourly ground level ozone concentrations at or above 0.06 ppm. Ozone injury is expected for sensitive vegetation at levels above this concentration (McLaughlin and Percy 1999). Figure 2.1g shows a mapping of ozone ppm-hr using three-year average data from ozone monitoring stations supplied by Environment Canada for (a) 1994-1996 and (b) percentage change in SUM 06 between 1985-1987 and 1994-1996. A decrease of 10 to 15% occurred over most of the area during this period, with decreases of 0 to 10% in the Mixedwood Plains ecozone.

Although a declining trend in daily maximum ozone concentrations in Canada has been identified, there are three regions in Canada where the national objectives for hourly ground level ozone (0.082 ppm, National Ambient Air Quality Objectives) are exceeded. These are the southern Maritimes, the Windsor-Quebec corridor and the lower Fraser Valley in British Columbia.

2.1.8 CLIMATE CHANGE AS MEASURED BY TEMPERATURE SUMS

Temperature is one of the many climate parameters that are routinely measured at weather stations. Mean monthly temperature observations have been made since 1895, but the sparseness of data in many areas prevents any assessment of trends or changes over time across large geographic areas such as ecozones. The weather station density required to reasonably characterize temperature change over time has only been in place in Canada since 1950. Gaps in Canada's climate-observing network exist, particularly in some northern and mountainous areas. Given these difficulties, interpolation techniques are required to estimate climate in most forested areas and results must therefore be interpreted with caution.

Mean monthly temperatures were obtained from the Meteorological Services at Environment Canada. From these data, degree-day (DD) totals—the cumulative temperature above a mean daily temperature of 5°C (DD>5)—can be estimated and compiled for the growing season. Mean minimum and maximum monthly temperature values were estimated over the period 1950 to 1995 using a climate interpolation technique that included digital elevation models (McKenney et al. 1996, Hutchinson 1995, Mackey et al. 1996). Monthly DD>5 and annual growing season DD>5 values were computed to construct a time series for analysis. For most of Canada's forests, the growing season typically extends from May through September. The greater the growing season DD>5 value, the warmer the climate, and typically, the more productive the region in terms of plant growth.

Table 2.1b illustrates the change in DD>5 sums compared with the 30-year average for 12 forested ecozones across Canada. The following observations can be made for the period 1950 to 1995.

- Annual temperatures have increased in Canada's west and north from 1.6 to 2.5°C, with the rate of warming ranging from 0.37 to 0.55°C/decade. In the east, little change is evident.
- Growing season degree-day temperature sum is an important climatic variable having significant influence on the growth and distribution of forest tree species in Canada. Growing season temperatures have increased by 0.15 to 0.95°C, with changes ranging from 0.04 to 0.21°C/decade.
- In Canada's west and north, the increase in growing season temperatures has been lower than the annual temperature increase, indicating that much of the annual warming is occurring outside of the growing season. In the east, the opposite appears to be the case, with the growing season warming at a greater rate than the annual temperature.
- Consistent with the increase in growing season temperature, growing season DD>5 sums have been increasing. There has been less warming in the Mixedwood Plains than anywhere else, while the greatest amount of warming has been in the Hudson Plains, Pacific Maritime and Boreal Shield ecozones.

Increased warming would appear to suggest that, where drought is not a limiting factor, growth and productivity of much of Canada's forest should have increased over the past 50 years. More research is required to understand the implications of climate change on the sustainability of Canada's forests. Temperature alone is not sufficient to describe climate change and variation. Moisture also influences growth, productivity, species range and natural disturbances of forests. Research is underway to permit a combination of temperature and moisture indices to be used in future reports in order to describe climate variations over time in Canada's forests.

TABLE 2.1b Rate of change in growing season degree day greater than 5°C, 1950-1995

Ecozone	Growing Season DD > 5°C Sums	
	1961-1990 Average	ΔDD>5 /Decade
Taiga Cordillera	213 ± 103	+24.8
Taiga Plains	860 ± 112	+21.7
Taiga Shield	409 ± 114	+17.8
Boreal Cordillera	408 ± 96	+19.1
Boreal Plains	1159 ± 98	+23.0
Boreal Shield	1058 ± 90	+27.6
Pacific Maritime	681 ± 101	+30.8
Montane Cordillera	679 ± 97	+20.9
Prairies	1472 ± 105	+ 24.4
Hudson Plains	815 ± 105	+ 32.4
Mixedwood Plains	1773 ± 74	+7.3
Atlantic Maritime	1352 ± 85	+19.3

Source: McKenney 1999

ELEMENT 2.2
ECOSYSTEM RESILIENCE

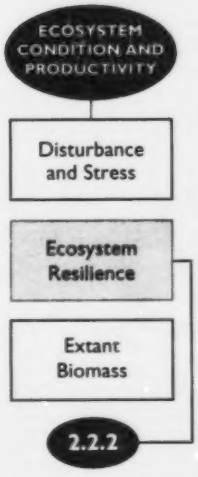
ELEMENT OVERVIEW

Evolution has provided forest ecosystems with elaborate mechanisms for recovery from disturbances. This capacity for recovery may be described in terms of resilience (return time) and is a measure of an ecosystem's ability to maintain its integrity despite disturbances. Resilience reflects the persistence of ecosystems and their capacity to absorb changes and disturbances while maintaining productivity levels and relationships among populations of organisms. This element focuses on the potential for populations to recover from very low levels through an adequate regenerative capacity and a balanced distribution of forest types. To date, no common methodology has been developed for determining resilience. Regeneration of timber productive forest lands following human disturbances such as harvesting (Indicator 2.2.2) is an indication of the sustained productivity of forest ecosystems.

Prompt regeneration of harvested areas is essential for maintaining a supply of timber for the future. Vegetation of some kind will eventually become established on all harvested sites, unless the soil to support it is lost or dramatically degraded. Productivity of future stands must equal or exceed that of the stands they replace and is dependent on viable populations of many species in addition to the timber species of economic importance. For example, the growth of many tree species is enhanced through symbiotic relationships with microorganisms.

Canada's forests can be divided into two categories—even-aged and uneven-aged. Most Canadian forests are even-aged. The trees in even-aged forests reach maturity at the same time and the tree species are adapted to regenerate forest lands after major disturbances, such as forest fires. Management of these forests for timber production attempts to mimic this natural life cycle through clearcut, seed-tree and shelterwood harvesting. Most sites regenerate naturally. Those that do not have an adequate stocking of commercial species are aided by planting or seeding.

Provincial planting and seeding programs were intensified in the 1980s under the federal–provincial forest resource development agreements (FRDAs) and through new provincial legislation which enforced better regeneration practices. By the early 1990s, planting programs had largely eliminated the backlog of treatable, understocked sites, and several provinces were able to scale back their planting programs. In 1997, 434 000 hectares were planted across Canada.



Current harvest and regeneration practices do not appear to be a constraint to sustainable timber supplies at the national level. Using data supplied from provincial and territorial government agencies, the REGEN model output indicates that the majority of harvested areas are regenerated successfully within 10 years of harvest.

INDICATOR REPORT

2.2.2 PERCENTAGE OF AREA SUCCESSFULLY NATURALLY REGENERATED AND ARTIFICIALLY REGENERATED

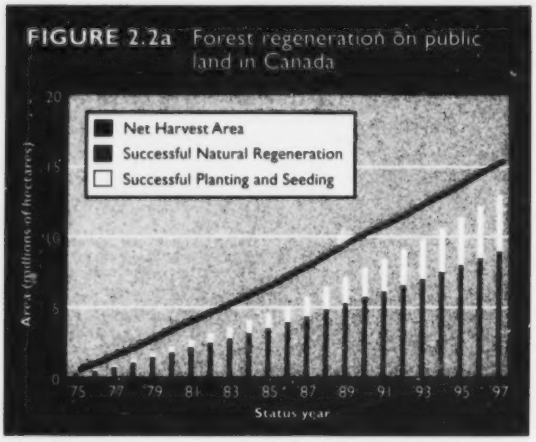
Reforestation is mandatory on public land in Canada. Since the 1980s, most provinces and territories have passed legislation or signed agreements requiring logging companies to ensure regeneration on sites they harvest. Prior to 1979, the provincial government was responsible for the reforestation of all lands harvested in Manitoba. Since 1979, Manitoba has ensured regeneration by making reforestation requirements a condition of all forest licence agreements with forest companies. Alberta has had mandatory reforestation requirements for all tenures since the 1960s. Foresters' options include selection cutting in forest types that are suited to uneven-aged management, clearcutting and scarifying to promote natural regeneration, or adopting a modified harvesting method that will protect advance regeneration. Clearcut areas may also be regenerated by planting or seeding.

Harvesting techniques are rapidly being improved. New techniques are being applied to protect advance

regeneration, emulate natural disturbances and encourage natural regeneration. In Ontario, for example, the use of guidelines for the protection of wildlife habitat and other cultural, ecological and environmental values is legally mandated. In Quebec, "cutting with protection of regeneration and soils" was mandated by the 1987 *Forest Act*. This technique accounted for 22% of the area harvested under even-aged management when the Act came into force. Ten years later, it accounted for 93%.

Indicator 2.2.2 reports on the extent of successful regeneration on over 15 million hectares of public timber productive forest lands harvested under even-aged management between 1975 and 1997. The reported information is based on data supplied from provincial and territorial government agencies compiled using the REGEN model. This model links harvesting and silvicultural activities with regeneration status of harvested lands to report on regeneration in even-aged forests. Regeneration status is based on three factors: stocking of commercial species; crop tree density; and the competition from non-crop vegetation. Uneven-aged stands are not included in the land base described in this indicator.

FIGURE 2.2a Forest regeneration on public land in Canada



Source: National Forestry Database, REGEN

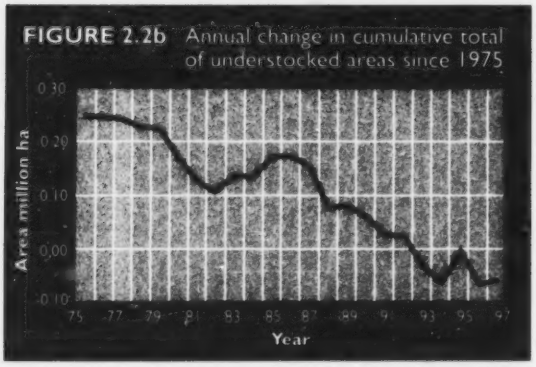
Figure 2.2a shows regeneration on public timber productive land under even-aged management. The net harvest area is indicated by a line. This is the area that is managed for regeneration and does not include harvested areas that are set aside for permanent roads. The area regenerated is shown as columns, including natural regeneration and successful planting and seeding. Areas indicated as "successfully regenerated" include some recently harvested areas that are expected to become restocked without further treatment. The areas shown in this graph are cumulative: the value for each year represents the area harvested or regenerated since 1975, up to and including that year.

Natural regeneration plays a much larger role in Canadian forestry than planting or seeding, accounting for 70% of the estimated 12.9 million hectares of forest land successfully regenerated in 1997.

In Figure 2.2a, the space between the line and the top of the column represents the area that remained understocked each year. "Understocked" refers to areas that have not yet regenerated with enough trees of commercial species. Most of this land will be regenerated by planting or seeding as required by law. The remainder did not regenerate with enough trees of commercial species within an acceptable time frame. These areas are not barren, having regenerated with a variety of woody and herbaceous plants, but do not contain sufficient trees of commercial species to be considered successfully regenerated for commercial purposes.

Figure 2.2b shows that the annual change in understocked area decreased substantially with improved regeneration practices and technology, and substantial investments in planting the treatable backlog of persistently understocked areas. Despite this and largely due to increasing areas harvested, the cumulative understocked area increased to 2.7 million hectares in 1992 (Figure 2.2a). By 1997 it decreased to just under 2.4 million hectares, roughly equivalent to the area harvested over a three-year period.

FIGURE 2.2b Annual change in cumulative total of understocked areas since 1975



Source: National Forestry Database, REGEN

The REGEN model indicates that the majority of harvested areas are regenerated successfully. Additional comprehensive localized data are required to further substantiate these observations.

ELEMENT 2.3
EXTANT BIOMASS

ELEMENT OVERVIEW

Extant biomass represents the mass of living organisms inherent in an ecosystem and is a reliable indication of net performance. It is an integrating measure of forest ecosystem condition (health and vitality of all species and types). Evidence that the condition of forests is constant or improving indicates that they are being managed in a sustainable way.

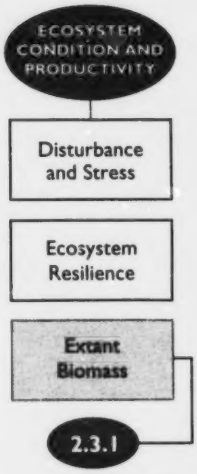
The biomass production of tree species is one indicator of the ability of ecosystems to support and maintain life. The amount of new wood added to a tree over a given period is referred to as the increment. This can be measured on one tree or on a stand of trees as an increase in diameter, basal area, height, volume, quality or value.

Mean annual increment (MAI) is the average net annual increase in the yield (expressed in terms of volume per unit area) of living trees to a given age, and is calculated by dividing the yield of a stand of trees by its mean age. The MAI of a stand is dependent on a number of factors, including climate and elevation, soil conditions, forest management practices, and of course, age. MAI can thus only be determined in even-aged stands or for trees of known age. Loss of biomass to mortality, insects and diseases is reflected in MAI values; a reduction in these losses results in an increase in MAI.

INDICATOR REPORT

2.3.1 MEAN ANNUAL INCREMENT BY FOREST TYPE AND AGE CLASS

Indicator 2.3.1 presents the MAI values from *Canada's Forest Inventory* (Lowe et al. 1996). The values were calculated for groups of comparable stands at maturity. Since MAI to maturity is a long-term average, the values presented in this report may not reflect current growth in Canada's forests. They serve as a general overview of how growth rates vary in Canada's ecozones (Element 1.1).

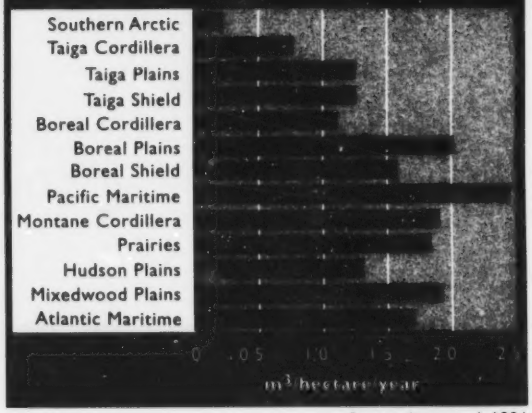


If over time, productivity (as measured by average MAI to maturity) is not maintained or enhanced in forest areas from which timber is to be harvested, the sustainable harvest from those areas will be jeopardized, and their ability to support and maintain life forms diminished.

Figure 2.3a shows that the Pacific Maritime ecozone on the west coast of British Columbia—an area known for its long growing season and favourable climate—has the highest MAI, averaging 2.5 m^3/ha/yr. The northernmost forested ecozone (Southern Arctic) has the lowest MAI, averaging 0.2 m^3/ha/yr.

Ideally, information for this indicator would be derived from tree measurements taken every five to ten years on permanent sample plots located in the full variety of forest types and conditions found in Canada. This type of information would reveal changes over time in forest ecosystem productivity, health and vitality. An even better indicator would be the monitoring of total forest biomass, not just trees in stands of potential commercial interest. At the Canadian Forest Service, a project is underway (Extended Collaboration for Linking Ecophysiology and Forest Productivity [ECOLEAP]) to develop a

FIGURE 2.3a Net mean annual increment by ecozone



Source: Lowe et al. 1996

tool, using remote sensing, that will permit the estimation of forest productivity at the landscape level (Bernier et al. 1999).

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CRITERION 3

CONSERVATION OF SOIL AND WATER RESOURCES

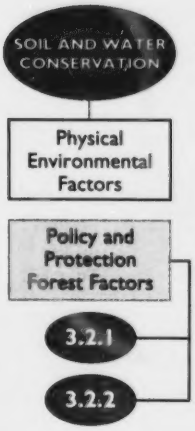
INTRODUCTION

3.2 Policy and Protection Forest Factors

- 3.2.1 Percentage of forest managed primarily for soil and water protection
- 3.2.2 Percentage of forest area having road construction and stream crossing guidelines in place

INTRODUCTION

CONSERVATION OF SOIL AND WATER RESOURCES



Soil and water are essential components of forests, sustaining the functioning and productive capacity of forest ecosystems. Criterion 3 discusses the conservation of soil and water resources. The primary reason for soil conservation is the maintenance of the living substrate for forest stands, whereas water conservation is important for the provision of potable water for humans and wildlife and the provision of suitable aquatic environments for plants and animals. Measures that maintain the quantity and quality of soil and water within and through forested ecosystems are addressed by this Criterion.

The long-term productivity and resilience of the forest are dependent upon the maintenance of appropriate levels of soil oxygen, nutrients and organic matter, in addition to abundant and clean water. In order to ensure that terrestrial and aquatic ecosystems are maintained, policies must be enacted to provide for specific management practices or the protection of sensitive sites. With respect to aquatic systems, policies that address stream crossings, watershed management and riparian areas will help maintain water flow patterns, water levels and water quality.

The construction of access roads and other forestry practices may impact on the quantity and quality of soil and water in a number of ways. These include soil erosion and compaction, siltation of aquatic habitats, flooding and increased water temperatures. The rapid regeneration of forests following harvesting is essential for maintaining moisture and nutrient levels in the soil, minimizing disruptions in stream flow rates and timing and minimizing soil erosion, stream siltation and downstream water quality effects.

Element 3.2 *(Policy and Protection Forest Factors)* discusses the guidelines and management objectives in place in Canada for the protection of soil and water resources in forest ecosystems.

ELEMENT 3.2 POLICY AND PROTECTION FOREST FACTORS

ELEMENT OVERVIEW

Sustainable forest management acknowledges the critical role of forest ecosystems in regulating the flow of water and in preserving water quality and quantity for all living creatures. Protection of the soil retains the nutrient capital in the forest, and in turn maintains the quality of aquatic and riparian environments.

Riparian areas, the interfaces between terrestrial and aquatic ecosystems, are often considered the most valuable component of a forest landscape because they are very productive and support a diversity of plants and animals not found elsewhere. Riparian buffer zones represent the last effective natural buffer after landscape alteration to help mitigate or moderate the impacts of forest harvesting or other land uses.

Sustainable management dictates that particular attention be paid to the maintenance of environmentally sensitive forest areas such as streams, riparian zones and steep slopes. Alterations to natural stream flows, whether caused by control structures, such as hydro power dams, or natural catastrophes, such as unusually heavy rainfall, can increase water flows and lead to reduced water quality and aquatic habitats for fish and other organisms, as well as increased turbidity of water due to soil siltation and erosion. The implementation of road construction and stream crossing regulations or guidelines can minimize distur-

bances to terrestrial and aquatic ecosystems. In recent years, provinces and territories have significantly increased and upgraded guidelines for both public and private lands in order to protect streams, riparian zones, steep slopes and other sensitive forest sites.

It is important that measures be implemented in managed forests to protect water courses in order to reduce soil degradation and maintain water quality. The area of land specifically allocated to soil and water quality protection is an indication of the extent to which these elements are specifically considered in forest management (Indicator 3.2.1).

The majority of provinces and territories in Canada have established guidelines for the location, design, construction, maintenance and deactivation of access roads and stream crossings (Indicator 3.2.2). The overarching objective of these guidelines is to protect and maintain the natural conditions where forest projects are to be implemented by defining appropriate practices for working in sensitive areas. The environmental protection requirements for road construction are more stringent for sensitive areas in order to minimize impacts.

INDICATOR REPORTS

3.2.1 PERCENTAGE OF FOREST MANAGED PRIMARILY FOR SOIL AND WATER PROTECTION

Initiatives such as municipal watersheds and areas managed by water conservation authorities are intended to promote soil and water conservation; however, at this time only about 5% of the total forest landmass of Canada is affected by these measures. Watershed management is a high priority. Protection is achieved through a combination of guidelines, legislation and conservation practices.

The creation of riparian buffer zones is now standard practice throughout the country. All provinces and many large forest companies have guidelines that constrain activities in riparian areas and around water bodies. The 20- to 50-metre riparian zones currently observed amount to 4 to 10 hectares of reserve per kilometre of stream. Depending on natural variations in the number and distribution of water courses, it is estimated that riparian buffers represent 10 to 20% of harvested areas.

Because provincial agencies do not gather data on the amount of land protected specifically for the purposes of conserving soil and water, it is not possible at this time to provide a quantitative report on the amount of land managed or removed from production as a result of soil and water quality protection practices. Case studies are provided in order to illustrate the types of guidelines and policies that have been put in place in three Canadian provinces to sustainably manage forest ecosystems.

Case Study 1 Newfoundland and Labrador

The Corner Brook Lake Watershed in Western Newfoundland drains an area of approximately 107 square kilometres. It contains vast areas of lakes, marshes, barrens and forest as it stretches nearly 25 kilometres from southeast of Corner Brook northwest into the Bay of Islands. The Western Newfoundland ecoregion where the watershed is located is considered one of the province's most favourable sites for forest growth. The Corner Brook subregion is characterized by heavily forested areas with a rugged topography and rich productive soils.

In recent years, increased resource development and recreation activity in water supply areas have given rise to concern about the safety, cleanliness and abundance of drinking water. Newfoundland and Labrador's *Environment Act* provides for the protection of water supply sources by prohibiting or restricting development activities with the potential to impair water quality in designated areas. In an effort to promote cooperation on this front, the Corner Brook Watershed Monitoring Committee was appointed in 1989 by the provincial Minister of Environment and Labour. Membership is composed of provincial and municipal officials as well as industry representatives. The purpose of the Committee is to protect and enhance the quality of the Corner Brook water supply for current and future generations through wise and efficient management practices. To accomplish this, the Committee developed guidelines to ensure that timber harvesting activities are not detrimental to the quality and quantity of the water supply. These guidelines have resulted in protected water supplies.

Water samples were collected from the Corner Brook Lake Watershed between February 1989 and October 1996. Values never exceeded recommended or regulatory limits for nitrogen, chloride, sodium, total dissolved solids or specific conductance. Phosphorous, total suspended solids and turbidity were occasionally identified; however, all were within recommended regulatory limits. Water colour is the only parameter that consistently failed to meet the *Canadian Water Quality Guidelines*. This is the result of the high natural organic content found in Newfoundland's water.

Case Study 2 Alberta

The Alberta Green Area includes a land surface of approximately 350 554 km^2 (excluding Wood Buffalo National Park) set aside for multiple uses other than agriculture (see p. 50). Watershed protection is a high management priority for the Green Area and is achieved through a combination of policies, legislation and conservation practices. A large portion of the Eastern Rocky Mountains is designated as forest reserve. Alberta's *Forest Reserves Act* states that: "All forest reserves within Alberta are set apart and established for the conservation of the forests and other vegetation in the forests and for the maintenance of conditions favourable to an optimum water supply."

The Alberta government, in conjunction with the Canadian Forest Service, carried out a number of case studies to measure the effects of forest operations on water yield and quality, fisheries and fish habitat, and stream flow in several different water basins. The results of those studies were used in the development of provincial ground rules and environmental protection manuals, and the refinement of the United States Environmental Protection Agency's *Water Resources Evaluation of Non-point Silvicultural Sources* (WRENSS) water yield assessment procedure. Study results have also contributed to the development of models to restrict the increase in annual water yield to less than 20% over undisturbed conditions in some locations and to assess potential watershed impacts due to logging.

The provincial *Timber Harvest Planning and Operating Ground Rules* and *Forest Management Area Ground Rules* apply to all forestry operations in the Green Area. They include the following watershed protection provisions:

- All watercourses are classified. Standards and guidelines for streamside buffers, roads, landings and bared areas, tree felling and equipment operation are based on these classifications.
- Treed, or otherwise vegetated, buffers are required along most watercourses.
- Guidelines are in place for the planning, construction, maintenance and abandonment of roads, landings and campsites.
- Guidelines are provided for locating, designing and constructing watercourse (stream) crossings. The rate of harvest is constrained (2 or more passes) allowing for some hydrological recovery. Passes are separated by approximately 20 years.
- Block size is limited; the dimensions and pattern of the clearings are significant.
- Forest protection from fire and insect outbreaks is prescribed.
- Harvesting is usually restricted to slopes of less than 45 percent.
- Detailed cut block layouts are required on sensitive or complex sites.
- Pre-disturbance watershed assessments are required on designated sites.

A Policy for Resource Management of the Eastern Slopes covers the 90 000 km^2 of mountains and foothills along the Rocky Mountains. Watershed management is the highest priority in the overall management of the Eastern Slopes. Watershed objectives are:

- To manage and develop natural resources in the region to maintain or increase the volume of water yield and the natural timing of surface and sub-surface discharge.
- To manage headwaters in the region to maintain recharge capabilities and protect critical fisheries habitat.
- To intensively manage the South Saskatchewan River Basin for water supply stability.
- To manage the North Saskatchewan and Athabaska River watersheds to maintain natural flows and provide the option for future increases in water yields through intensive management.

In addition to the guidelines and objectives mentioned above, foresters and other users of the forest are subject to a variety of federal and provincial legislation and regulations that serve to protect soil and water resources. In terms of provincial measures, these include: the *Forest Reserves Act*; the *Soil Conservation Act* (which applies particularly to agricultural land use); the *Public Lands Act* (granting to the government all title to water beds and shores and providing penalties for injury and erosion); the Alberta *Water Act* (requiring qualified professionals to be involved in the design of watercourse crossings); and regulations governing pesticide use, pollution and erosion control. Federally, the application of the *Canadian Environmental Assessment Act*, the *Fisheries Act*, and the *Navigable Waters Protection Act* also contributes to the protection of watersheds and soil.

Case Study 3 British Columbia

British Columbia has some of the wettest local climates and steepest terrains in Canada. To ensure the protection of soil and water on all provincial public land and private lands under tenures, the *Forest Practices Code of British Columbia Act* includes extensive planning and practice requirements. Planning requirements vary with the situation, and may include a number of assessments to identify sensitive areas in which more restrictive forest practice requirements apply. In addition to stream classification, assessments may be required to address cumulative impacts of resource development in whole watersheds, terrain stability on potentially unstable soil areas, soil degradation hazards and gullies. Detailed practice requirements address road and stream crossing layout and design, use of pesticides in watersheds, refuelling of equipment, and restriction of timber harvesting in riparian management areas. Clearcutting is usually not permitted on areas with a high likelihood of landslides.

By way of illustration, the requirements for riparian management areas around fish-bearing streams are described in Table 3.2a. Timber harvesting is not permitted in the riparian reserve zone on either side of the stream, and is restricted in the riparian management zone which extends beyond the reserve zone.

TABLE 3.2a Minimum widths of riparian reserve and management zones on either side of streams in British Columbia

Stream width (m)	Riparian Class	Riparian Reserve Zone (m)	Riparian Management Zone (m)
>20	S1	50	20
>5 ≤ 20	S2	30	20
1.5 ≤ 5	S3	20	20
<1.5	S4	0	30

Source: British Columbia Ministry of Environment, Lands and Parks—Resource Stewardship Branch 1999

The requirements for streams without fish are less stringent, with only a riparian management zone in which timber harvesting is restricted, as shown in Table 3.2b.

TABLE 3.2b Minimum width of riparian management zones on either side of streams in British Columbia

Channel width (m)	Riparian Class	Riparian Management Zone (m)
>3	S5	30
≤3	S6	20

Source: British Columbia Ministry of Environment, Lands and Parks—Resource Stewardship Branch 1999.

Similar riparian management requirements apply to various classes of lakes and wetlands.

The *Forest Practices Code of British Columbia Act* provides special protection for community watersheds, which provide water for human consumption. More than 1.5 million hectares of public land are managed as 480 community watersheds. Forest operations in community watersheds require the joint approval of the Ministry of Environment, Lands and Parks and the Ministry of Forests.

In community watersheds, the riparian reserve zone and the riparian management zone requirements in Table 3.2a apply to all streams, including streams without fish. A watershed assessment procedure is always required in community watersheds to determine cumulative impacts of resource development. Terrain stability hazard mapping and soil erosion potential mapping are required before forest development can take place. A terrain stability field assessment by a geoscientist or other qualified professional is required in

areas with a risk of landslides. Timber harvesting is not permitted in areas with a high likelihood of landslides, while clearcutting is restricted where there is moderate likelihood of landslides. Bladed trails are not permitted in areas with a surface soil erosion hazard or where there is moderate risk of sediment delivery to streams. Community water supply intakes and infrastructure must be protected by any forest development.

3.2.2 PERCENTAGE OF FORESTED AREA HAVING ROAD CONSTRUCTION AND STREAM CROSSING GUIDELINES IN PLACE

Road construction may affect water quality in terms of both chemistry and turbidity. If roads are constructed on acidic soils, water quality may be affected by the increased concentrations of dissolved nutrients and organic chemicals and by decreased pH levels. Guidelines for road construction and stream crossings on public forest lands are in place in the majority of provinces and territories in Canada. These guidelines have improved environmental conditions while minimizing the environmental degradation associated with road construction and use. They have also contributed to a reduction in construction costs and protection of sensitive aquatic species. Remediation of forest soils, compacted as a result of road construction, has been achieved in some areas by tilling and planting.

The implementation of guidelines has also helped limit the number of stream crossings, thereby reducing the chances of stream and tributary siltation in poorly drained areas, decreasing sedimentation in streams and damage to migrating fish and their spawning areas, and reducing disturbance near streams. Available information shows that the percentage of forest area that is subject to these guidelines ranges from 57% in Newfoundland and Labrador to 100% in British Columbia and Manitoba.

In Ontario, the *Crown Forest Sustainability Act*, in effect since 1995, requires that forest management consider all forest values. If forest management plans are not complied with, or if damage to water, soil, plant life or habitat occurs in a public forest, the responsible party must repair the damage and prevent further degradation. The application of *Environmental Guidelines for Access Roads and Water Crossings* is mandatory for all forest access roads and water crossings in public forests in Ontario.

Stream crossing guidelines were established in Manitoba to ensure free fish passage, protect stream beds and banks from accelerated erosion and prevent the introduction into streams of substances deleterious to fish or fish habitat. These guidelines also provide practical advice and information on mitigation measures to protect fish and fish habitat. Although designed for application to crossings for temporary and permanent access roads, the concepts are also relevant for crossings associated with transmission lines, cable crossings, pipelines and railroads.

The *Forest Practices Code of British Columbia Act*, which applies to all provincial public and private lands under tenures, contains extensive regulations for the layout, design, construction, maintenance and deactivation of roads and stream crossings. A terrain stability field assessment is required on potentially unstable slopes in order to minimize the risk of land slides and other disturbances to the surrounding area.

Road construction and stream crossing guidelines are as comprehensive for private lands as for public land, even if they are not always specifically addressed in formal policies.

In Newfoundland and Labrador, approximately 90% of private forest land is affected by either protective guidelines or legislation. Landowners adhere to guidelines addressing the preservation of water, fish and their habitats, and soil stability.

In Quebec, the approximately 120 000 private forest owners are becoming increasingly sensitized to the importance of protecting forested land. The government policy on forest protection to which they are subject not only defines the principal components of natural forests, but also determines minimum standards of protection for streams, including stream crossings. Municipalities affected by this policy have integrated it into their regulations for forest management plans.

In May 1995, private land owner organizations met at the *Quebec Summit on Private Forests* to collaborate on a system to protect and develop private forest land. After the Summit, 17 regional development agencies were created to provide guidance on the implementation of measures to protect soil, water and ecological resources located on private forest lands.

TABLE 3.2c Road construction and stream crossing guidelines on private lands in Nova Scotia

Target	Guideline, regulation, law, etc.	General description	Impact
Soil stabilization	• *Forest Access Roads, Planning and Construction Manual** (1982/1991)	• Locate on high ground with good drainage. • Avoid bogs, swamps, poorly drained areas and excessive slopes.	• Reduced erosion and sedimentation.
Road design, construction and maintenance	• *Forest Access Roads, Planning and Construction Manual* (1982/1991) • *Environmental Standards for the Construction of Forest Roads and Fire Ponds in Nova Scotia* (1983/1985) • *Woodlot Roads, Stream Crossings* (1992) • *Environment Act* (1994)	• Design roads to minimize the length required to service the management area now and in the future. • Consider the topography, soil conditions and stream crossings at the design stage. • Construction of stream crossings carried out only between May 15 and Sept 15 without special permission from the Department of Environment. • Coffer dams and stream diversion permits required when bridge abutments are constructed in stream beds with water present. • Maintain road surface with grading to ensure surface runoff to the ditches. • Inspect and repair ditches and drainage structures for proper water removal.	• Improved road network with reduced environmental impact. • Minimal disruption to the natural drainage patterns. • Reduced erosion and sedimentation.
Riparian zones	• *Environmental Standards for the Construction of Forest Roads and Fire Ponds in Nova Scotia* (1983/1985) • *Forest Wildlife Guidelines and Standards for Nova Scotia* (1989) • *Forest Access Roads, Planning and Construction Manual* (1982/1991) • *Woodlot Roads, Stream Crossings* (1992)	• During construction, ground vegetation to be left undisturbed in ditch areas within 30m of stream crossing (on slopes > 30%, 40m buffer). • Take-off ditches established at the start of the buffer zone. • No landings to be constructed within 100m of stream crossings. • Machines excluded from within 10m of stream for forestry operations. • Machinery with high floatation tires may operate to within 5m of stream. • Riparian zones required on all watercourses that appear on 1:50 000 topographic map.	• Protection of environmentally sensitive areas.
Stream crossings	• *Environmental Standards for the Construction of Forest Roads and Fire Ponds in Nova Scotia* (1983/1985) • *Forest Wildlife Guidelines and Standards for Nova Scotia* (1989) • *Woodlot Roads, Stream Crossings* (1992) • *Environment Act* (1994)	• During road construction formal approval from the Department of Environment prior to starting any work within 30m of a stream. • Temporary fords may be permitted from June 1- Sept 30. • For forestry operation temporary structure or portable bridge is required to cross all watercourses appearing on 1:50 000 topographic maps.	• Maintained grading on road surface ensures runoff to the ditches. • Maintained ditches and drainage structures ensures proper water flow.

**Policy on woodlots receiving assistance from government programs. Encouraged on all private lands.*

Sources: Braithwaite 1992, Nova Scotia Department of Environment and Department of Fisheries and Oceans Canada 1983, Nova Scotia Department of Natural Resources 1989, Talbot 1991

Case Study Nova Scotia

The adoption and application of guidelines in Nova Scotia has led to the creation of mechanisms that ensure the protection of forested land. The first set of guidelines, introduced in 1983, was entitled *Environmental Standards for the Construction of Forest Roads and Fire Ponds in Nova Scotia.* Since then, concerns about road construction and stream crossings have been addressed in the *Forest Wildlife Guidelines and Standards for Nova Scotia* (1989), and articulated in a publication entitled *Woodlot Roads, Stream Crossings* and in the *Environment Act* (1994). Pursuant to the *Environment Act,* formal approval is required from the Nova Scotia Department of Environment prior to undertaking any work within 30 metres of a stream. Portable bridges are required for all forestry operations crossing watercourses with a view to reducing sedimentation by keeping heavy equipment out of streams.

Nova Scotia's guidelines for road construction and stream crossings on private forest lands are included in the policies that provide direction for public land. Table 3.2c describes the guidelines in place and their impacts.

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CRITERION 4

FOREST ECOSYSTEM CONTRIBUTIONS TO GLOBAL ECOLOGICAL CYCLES

INTRODUCTION

4.1 Contributions to Global Carbon Budget

- 4.1.1 Tree biomass volumes
- 4.1.2 Vegetation (non-tree) biomass estimates
- 4.1.3 Percentage of canopy cover
- 4.1.4 Percentage of biomass volume by general forest type
- 4.1.5 Soil carbon pools
- 4.1.6 Soil carbon pool decay rates
- 4.1.7 Area of forest depletion
- 4.1.8 Forest wood product life cycles
- 4.1.9 Forest sector CO_2 emissions
- 4.3.2 Fossil carbon products emissions
- 4.4.1 Recycling rate of forest wood products manufactured and used in Canada

4.2 Forest Land Conversion

- 4.2.1 Area of forest permanently converted to non-forest land use (for example, urbanization)
- 4.2.2 Semi-permanent or temporary loss or gain of forest ecosystems (for example, grasslands, agriculture)
- 3.1.2 Area of forest converted to non-forest land use (for example, urbanization)

4.3 Forest Sector CO_2 Conservation

- 4.3.1 Fossil fuel emissions
- 4.3.3 Percentage of forest sector energy usage from renewable sources relative to total sector energy requirement

4.4 Forest Sector Policy Factors

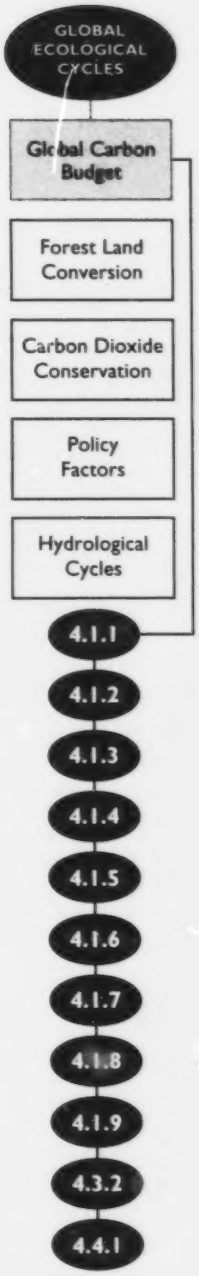
- 4.4.2 Participation in the climate change conventions
- 4.4.4 Existence of forest inventories
- 4.4.5 Existence of laws and regulations on forest land management

4.5 Contributions to Hydrological Cycles

- 4.5.1 Surface area of water within forested areas

INTRODUCTION

FOREST ECOSYSTEM CONTRIBUTIONS TO GLOBAL ECOLOGICAL CYCLES



Forests occupy roughly one third of the Earth's land surface, and Canada has approximately 10% of the Earth's forests. Because of their size, forests play a major role in the functioning of the biosphere. Global ecological cycles are a complex of self-regulating processes responsible for recycling the Earth's limited supplies of water, carbon, nitrogen and other life-sustaining elements. Understanding the role forests play in these cycles is essential for the development of sustainable forest practices.

Carbon budgets that estimate the balance between carbon storage and carbon release from forests and forest products indicate the nation's contribution to atmospheric enrichment. Element 4.1 *(Contributions to Global Carbon Budget)* examines the role of forests as sinks or sources of atmospheric carbon and describes the impact of disturbances such as insects, fire and harvesting on carbon movement among the atmosphere, trees and soils.

Carbon budgets are sensitive to forest land conversions because temporary or permanent removal of forest alters the land's capacity to absorb and store carbon. Element 4.2 *(Forest Land Conversion)* seeks to determine the amount of forest land being converted for other uses, such as urbanization or agriculture, as well as land being converted back to forest.

Forest industries consume a large amount of energy in harvesting, transporting and converting timber into products. Element 4.3 *(Forest Sector Carbon Dioxide Conservation)* discusses the types of fuel used by the forest sector, and their impact on the global carbon budget. Efforts by the sector to improve energy efficiency through the introduction of cleaner-burning fuels are also discussed.

The sustainable management of Canada's forests is supported by various policies and policy frameworks. Element 4.4 *(Forest Sector Policy Factors)* examines Canada's international forestry commitments, the national policy frameworks that are in place for forest management, and the existence of forest inventories as a means of gauging Canada's capacity for measuring, monitoring, and implementing sustainable forest management.

Hydrological cycles describe the movement of water from the atmosphere to the soil, vegetation and bodies of water, and back to the atmosphere. Changes in the area of water surfaces within forested landscapes can indicate the impact of forest practices on hydrological cycles. Element 4.5 *(Contributions to Hydrological Cycles)* reviews current information on hydrological cycles.

ELEMENT 4.1 CONTRIBUTIONS TO GLOBAL CARBON BUDGET

ELEMENT OVERVIEW

Forests are extensive, ever-changing pools of carbon. Photosynthesis is the process by which trees absorb carbon dioxide (CO_2) from the atmosphere, convert it to carbohydrates, of which carbon is an essential ingredient, and store it in their roots, leaves, branches and trunks. Photosynthesis is the principal natural mechanism for removing greenhouse gases from the atmosphere. A vigorous and growing forest acts as a sink, storing carbon as it grows to maturity. When trees become diseased, when they decay, or when they are killed by fire, the stored carbon is released.

Through these processes, forests can become a source of CO_2 to the atmosphere and to the various environmental compartments.

Even through fire, only a small portion of the carbon accumulated in tree biomass is immediately released into the atmosphere. The rest ends up on the forest floor and in the soils, and subsequently decomposes over a long period of time. The whole process of carbon uptake by the forest, release to the atmosphere, or redistribution in soil and biomass components is called the carbon cycle.

The global carbon cycle (Indicators 4.1.1 to 4.1.9, 4.3.2, 4.4.1) represents the most important set of processes linking forests with climate change. The release or removal of CO_2 to and from the atmosphere impacts on global ecological cycles. Forests can act as either sinks or sources for atmospheric carbon, depending on whether they are principally storing carbon or releasing it. Knowledge of the influence of natural disturbances and human intervention on this role can indicate the type of forest practices required for sustainable management.

The Canadian Forest Service has been leading the development of a carbon budget model for Canada's forests. A carbon budget estimates the balance between carbon storage and release. Model estimates of the carbon currently stored in 404 million hectares of both managed and unmanaged Canadian forests, and changes in the carbon budget over the period 1920-1994, are outlined in this report.

Current estimates suggest that after having acted as a sink for atmospheric carbon for much of this century, Canada's forests became a net source in the mid-1980s. These estimates also indicate that the carbon budget of Canada's forests varies from ecosystem to ecosystem and on year to year, decade to decade and century to century time scales. The amount of carbon contained in the forest is strongly influenced by age distribution, growth processes and disturbances caused by fire, insects, disease and harvesting. The recent 25-year period of high fire and insect disturbances in the boreal forest will likely affect the dynamics of the forest carbon budget for decades to come.

Development of the carbon budget model for Canadian forests is not yet complete. Research is ongoing at the national and provincial levels to improve various model components and data quality and to determine how management activities such as harvesting, silvicultural practices, forest protection, and increased use of forest products affect the forest's contribution to the carbon cycle. Changes in the carbon budget estimates can be expected as new data are obtained, improvements to the model are made, and our understanding of forest carbon cycle processes increases.

INDICATOR REPORT

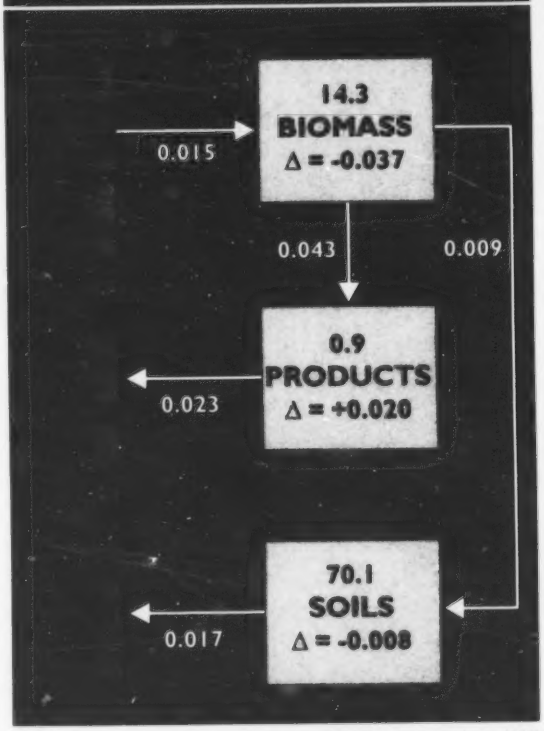
Indicators 4.1.1 to 4.1.9, 4.3.2 and 4.4.1 are combined and reported as one indicator to address the forest sector carbon budget. This report presents estimates of the carbon stored in 404 million hectares of both managed and unmanaged forests.

Carbon dioxide (CO_2) is one of the principal greenhouse gases in the Earth's atmosphere. Global forest ecosystems account for 100 Gt (gigatonne = 10^9t, t = 10^{12}g) of carbon (C), which is approximately 50% of the annual exchange of this gas with the atmosphere.

The forest carbon budget (Kurz and Apps 1999) consists of three major carbon pools or reservoirs: forest biomass; forest soils (which includes litter and coarse woody debris); and forest products. Forest ecosystems worldwide represent huge carbon pools in soil and standing biomass. The total modelled estimate for the amount of carbon stored in 1994 in all Canadian forests and related resources, excluding peatlands, is 85.3 Gt C, with 14.3 Gt C in standing vegetation biomass (trunks, branches, roots), 70.1 Gt C in forest soils and litter and 0.9 Gt C in forest products (the total accumulated from forest harvesting over the last 45 years after accounting for decomposition and burning of wastes, and including product exports). The forest products pool is small (0.3% of the total forest carbon pool), but it is important in terms of the annual movement of carbon between pools. The inclusion of peatlands in this reservoir increases the total to approximately 225 Gt C (Kurz and Apps 1999, Apps et al. 1999).

On a daily, seasonal and annual basis, carbon moves among pools and between pools and the atmosphere in a variety of ways. Figure 4.1a shows the estimated total carbon stored in the major carbon pools (rectangles) at the end of 1994, annual net transfers between pools (arrows) and change in pool storage (Δ) for the period 1990 to 1994.

FIGURE 4.1a Canada's forest carbon pool size and net transfers, 1990-1994 (gigatonnes of carbon [Gt C]. gigatonne = 10^9t)



Source: Kurz and Apps 1999

TABLE 4.1a Estimated total carbon storage and average annual change (Δ) in the carbon (C) pools in Canada's forests, 1990–1994

		SOIL		BIOMASS		ECOSYSTEM	
Ecoclimatic Province**	**Forest Area (million ha)*****	**Total GtC***	**ΔC Mt*/yr**	**Total Gt C**	**ΔC Mt/yr**	**Total Gt C**	**ΔC Mt/yr**
Arctic	0.6	0.2	0.2	0.0	-0.01	0.2	0.2
Subarctic	85.2	20.7	-9.8	1.5	-14.5	22.2	-24.3
Boreal West	97.6	13.4	26.8	3.1	-15.6	16.5	11.2
Boreal East	120.2	17.0	-46.4	2.3	1.0	19.3	-45.4
Temperate Forests	26.0	4.2	-3.6	1.4	-0.1	5.7	-3.7
Cordilleran	72.0	14.4	24.4	5.9	-7.6	20.2	16.8
Grassland	2.6	0.2	0.7	0.1	-0.04	0.3	0.6
Canada	**404.2**	**70.1**	**-7.8**	**14.3**	**-36.8**	**84.4**	**-44.6**

* Gt C (gigatonne = 10^9t carbon), Mt C (megatonne = 10^6t carbon), t = 10^{12}g.

** Ecologically based regions in which the plant succession and rate of growth are similar on similar sites are referred to as ecoclimatic regions. Ecoclimatic regions are grouped into ecoclimatic provinces (Canada Committee on Ecological Land Classification 1989).

***Biomass data are available for 404.2 million hectares.

Source: Kurz and Apps 1999

Table 4.1a shows the estimated carbon storage in 1994 for each of the major ecoclimatic provinces in Canada, and the estimated change in storage in each over the period 1990 to 1994. There is an overall loss of carbon from the forests, primarily from the Boreal East. The Arctic, Boreal West, Cordilleran and Grassland ecoclimatic provinces are sequestering carbon. Variation in carbon fluxes is evident within the Boreal ecoclimatic provinces, with the Boreal East losing carbon while the Boreal West is accumulating it.

TABLE 4.1b Biomass carbon content of Canada's forests by age class in 1994

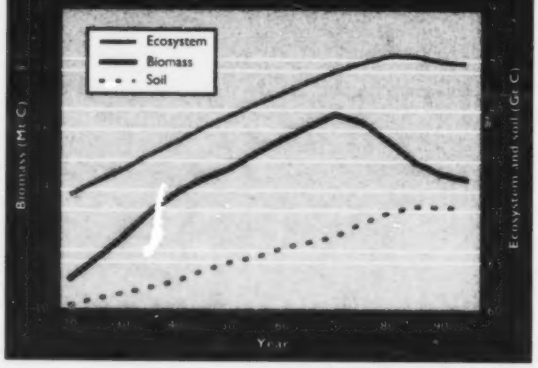
	FOREST AREA		BIOMASS	
Age Class (years)	**(million ha)**	**%**	**(Mt C)**	**Average (t C/ha)**
0-19	89.43	22.1	178.9	2.0
20-39	47.74	11.8	381.9	8.0
40-59	44.01	10.9	1 320.2	30.0
60-79	49.82	12.3	2 740.0	55.0
80-99	51.31	12.7	2 924.9	57.0
100-119	34.66	8.6	2 045.2	59.0
120-139	37.46	9.3	2 322.3	62.0
140-159	16.17	4.0	1 115.6	69.0
160+	33.63	8.3	1 352.5	40.2
Total	**404.23**	**100.0**	**14 381.4**	**35.6**

Source: Kurz and Apps 1999

Table 4.1b also shows that the quantity of carbon per unit area in Canada's forests increases with age class, peaking at 69 t/ha in the 140-159 year age class. The age class with the greatest amount of carbon in storage is the 80-99 year age class, which after the 0-19 year age class, covers the largest area of forest.

The carbon budget for Canada's forests has been modelled over the period 1920 to 1994 (Figure 4.1b). During this 75-year period, Canada's forests were a sink for atmospheric carbon, averaging 173 Mt C (megatonne = 10^6 t) per year. However, the magnitude of the sink has been steadily declining. Carbon losses began to occur in the 1970s in the biomass pool, followed by the soils pool in the 1980s. The rate of loss peaked at 75 Mt C/yr in the period 1985 to 1989. Estimates for the most recent period, 1990 to 1994, suggest that Canada's forests are still a net source of atmospheric carbon of about 44.6 Mt C/yr.

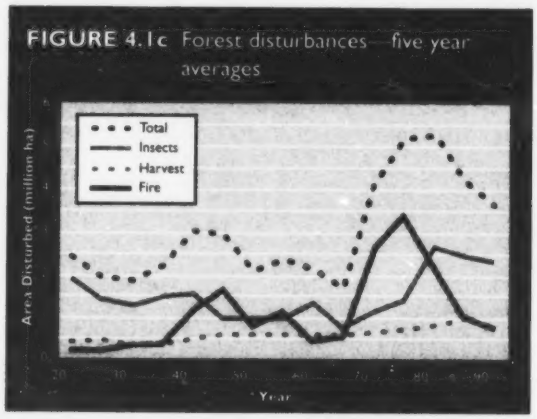
FIGURE 4.1b Carbon pools in Canadian forests



Source: Kurz and Apps 1999

Fire, insects and harvesting played a major part in the abrupt change in the forest's role from a sink to a source (Figure 4.1c). Fire disturbances (Indicator 2.1.3) in particular increased an estimated twofold. The potential impact of climate change on the frequency and intensity of forest disturbances related to fire and insects is a major concern with respect to carbon dynamics in Canadian forests (Kurz et al. 1992).

FIGURE 4.1c Forest disturbances – five year averages



Source: Kurz and Apps 1999

ELEMENT 4.2
FOREST LAND CONVERSION

ELEMENT OVERVIEW

Carbon budgets are sensitive to forest land conversion because replacement ecosystems usually have higher carbon turnover rates and lower storage capacity than forested lands. Irreversible forest removals have particularly negative and long-term impacts on carbon budgets.

Land-use change occurs throughout Canada in response to population growth, industrial development and changes in legislation, regulations and resource management practices. These changes include both the permanent (Indicator 4.2.1) and semi-permanent (Indicator 4.2.2) conversion of forest land to other uses and the conversion or reversion of land back to forest. The location, magnitude and extent of semi-permanent and permanent conversion of forest lands to other uses vary widely depending upon many factors. These include changes in population and associated urban expansion (Indicator 3.1.2), infrastructure development, agricultural product prices, demands for recreation and wildlife habitat, as well as land tenure and land- and resource-use policies. Reversion to forest land results primarily from the natural encroachment of trees due to fire suppression or the planting or regeneration of forests on agricultural lands.

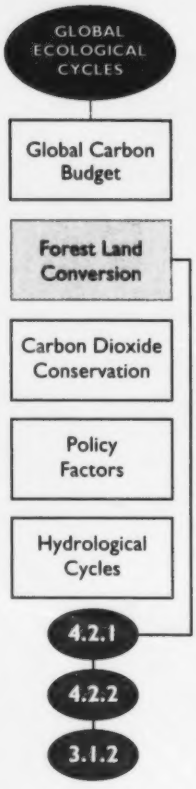
A number of provinces and territories have instituted legal and institutional mechanisms to control encroachment on forest lands. Research is ongoing into the development of remote sensing and other data sources to improve our ability to assess changes in the forest land base over time.

INDICATOR REPORT

4.2.1 AREA OF FOREST PERMANENTLY CONVERTED TO NON-FOREST LAND USE (FOR EXAMPLE, URBANIZATION)

4.2.2 SEMI-PERMANENT OR TEMPORARY LOSS OR GAIN OF FOREST ECOSYSTEMS (FOR EXAMPLE, GRASSLANDS, AGRICULTURE)

3.1.2 AREA OF FOREST CONVERTED TO NON-FOREST LAND USE, (FOR EXAMPLE, URBANIZATION)



Comprehensive time series information on changes in land cover and use is not available for Canada. Various approaches have been used to estimate the permanent and semi-permanent conversion of forest land to other uses. These include forest inventory comparisons, surveys, estimates of expansion of agricultural lands, and tracking of changes in legally designated forest lands. The reliability of these estimates varies considerably because many of the apparent changes in area can be attributed to new techniques, or changes in definitions, stratification and classification criteria and inventory standards and purposes. In addition, some differences may reflect changes in land use rather than land cover, for example, when areas previously available for forestry purposes are designated as wildlife reserves.

In order to fully report on forest land-use changes, baseline information is necessary to determine the potential impact of land withdrawals and to develop mitigative strategies. In addition to the geospatial location of converted lands and associated information on the forest resources, land tenure and administrative boundaries, information is also required on estimated productivity losses and the impacts on biodiversity and biodiversity values, the hydrological cycle, conservation status, the carbon budget and overall sustainability.

Results of a recent study (Global Forest Watch 2000) indicated that 26 million hectares of historically forested land—six percent of Canada's forest area—are now classified as cultivated or built up. The study showed that most of the clearing has occurred in the Carolinian and aspen parkland forest regions. The taiga forest has had very little clearing and less than 3% of the boreal forest has been cleared.

Indicators 4.2.1, 4.2.2 and 3.1.2 are combined and reported as one indicator through two case studies. The first details changes in forest land use in two provinces

pursuant to legal and institutional mechanisms to control encroachment on forest lands. The second examines changes in land use for Prince Edward Island based on forest inventory information.

Case Study 1 Changes in forest land use as governed by legal and institutional mechanisms

Alberta

Alberta's Green Area was established in 1948 to prevent settlement and indiscriminate squatting on certain areas of provincial lands that had been found unsuitable for agriculture. The lands were withdrawn from settlement, and disposition of surface rights was limited to commercial and industrial uses and other uses that the Minister of Lands and Mines considered to be in the public interest. Although the forestry potential was acknowledged, the lands were not formally designated as forest lands.

From 1948 to the mid-1960s, most changes to the Green Area took place as a result of local pressure to open additional lands for agricultural development. These alterations to the boundary were generally of a piecemeal nature, but the suitability of land for agricultural purposes was assessed before any new areas were opened up. In a few instances, boundary changes were made to consolidate the area to which forest fire protection was extended or for administrative reasons such as conformity with municipal boundaries.

In 1968 the Green Area was redefined as "Forest lands not available for agricultural development other than grazing." The order-in-council went on to state that "Provincial public lands are managed for multiple uses including forest production, water, recreation, fish and wildlife, grazing and industrial development." The area shown in Figure 4.2a includes Wood Buffalo National Park. Excluding the Park, there are approximately 350 554 square kilometres in the Green Area.

The data presented in Table 4.2a were drawn from the *Land Status Automation System* (Alberta Department of Environment 1990-1997) by searching for those types of activity that led to, or were likely to lead to, withdrawals of forested land from the Green Area over the period January 1, 1990, to August 1, 1999. The activity types were then classified as follows:

- "Industrial" includes all conversions except for agriculture and vegetation control easements. The major conversion categories include surface mineral leases, licence of occupation, roadways, easements and pipeline agreements.
- "Agriculture" includes cultivation permits and farm development leases and sales.
- "Other" includes vegetation control easements.
- "Changed Land Use" includes areas that are maintained as forest but that are not available for timber production, for example, forest research and sample plots and recreational areas.

FIGURE 4.2a Province of Alberta Green Area

Source: Alberta Department of Environment

TABLE 4.2a Conversion of forest land in Alberta

Type of Conversion	Area converted (ha)			
	Permanent	Semi-Permanent	Maintained as Forest Land	Total
Industrial	53 094			53 094
Agriculture		1 591		1 591
Other		1 687		1 687
Changed Land Use			5 363	5 363
Total	53 094	3 278	5 363	61 735

Source: Alberta Department of Environment 1990-1999

British Columbia

British Columbia has instituted mechanisms to control encroachment on forest and agricultural land through land reserve legislation and commissions. For example, the 1994 *Forest Land Reserve Act* is aimed at protecting the commercial forest land base by creating a forest land reserve. The Act places restrictions on the use of forest land and serves to minimize the impact of urban development and rural settlement. Designated forest reserve land includes approximately 15 million hectares of public land and 920 000 hectares of private land. Table 4.2b shows the area of permanent conversion of public forest land by period.

TABLE 4.2b Permanent conversion of forest land in British Columbia

Type of Conversion	Ha		
	1983–1989	1990–1997	Total
Urbanization and settlement	3 214	4 311	7 525
Transport and industry	2 519	2 523	5 042
Agriculture	12 245	13 094	25 339
Total	**17 978**	**19 928**	**37 906**

Source: British Columbia Ministry of Forests 1983-1997

Case Study 2 Changes in forest land use as determined by forest inventories

Table 4.2c provides an example of changes in forest land use as described in forest inventories using data from Prince Edward Island.

TABLE 4.2c Permanent conversion of forest land in Prince Edward Island, 1990-1997

Type of Conversion	Ha
Urbanization	436
Agriculture	4 672
Total	**5 108**

Source: Prince Edward Island Department of Agriculture and Forestry 1998

ELEMENT 4.3
FOREST SECTOR CO_2 CONSERVATION

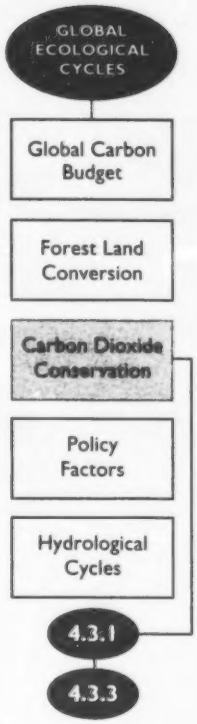
ELEMENT OVERVIEW

Concentrations of greenhouse gases in the atmosphere are increasing as a result of human activities. While the impact is not known with certainty, it is believed that humans are having a discernible influence on the global climate, and that future effects will be potentially more serious. The major source of emissions is the burning of fossil fuels, and the major greenhouse gas in terms of volume emitted is carbon dioxide (CO_2). Element 4.3 tracks forest sector CO_2 conservation by measuring, over time, the industry's relative dependence on fossil fuels for conversion of raw materials to manufactured products.

As a signatory to the *United Nations Framework Convention on Climate Change* (UNFCC 1997), and through its participation in the negotiations on the *Kyoto Protocol* to that convention (Indicator 4.4.2), Canada has committed to reduce its greenhouse gas emissions. One means of doing so is to improve energy efficiency—using less energy to produce a given quantity of product. Another way is fuel-switching—using cleaner-burning fuels in place of those that emit large amounts of CO_2. According to the emissions measurement guidelines of the *Intergovernmental Panel on Climate Change* (IPCC), burning biofuels such as wood residues (chips, sawdust, bark, etc.) and pulping liquor does not result in net emissions (IPCC 1997). This is because, under a sustainable forest management regime, it is expected that biofuel CO_2 emissions will be balanced by carbon removals associated with forest growth.

Indicator 4.3.3 summarizes energy use in forest harvesting and manufacturing operations. Indicator 4.3.1 describes the CO_2 emissions associated with these operations.

Based on the Statistics Canada energy-use data for the period 1980 to 1997, Environment Canada and Natural Resources Canada estimate total CO_2 emissions from the use of fossil fuels by the forest sector and from the production of the electricity it purchases. The data show that due to the industry's fuel-switching efforts and increased energy efficiency, fossil fuels are becoming a less important fuel source compared with renewable fuels, and that CO_2 emissions have not grown despite significant increases in energy use and production.



INDICATOR REPORT

4.3.1 FOSSIL FUEL EMISSIONS

4.3.3 PERCENTAGE OF FOREST SECTOR ENERGY USAGE FROM RENEWABLE SOURCES RELATIVE TO TOTAL SECTOR ENERGY REQUIREMENT

Indicators 4.3.1 and 4.3.3 are combined and reported as one indicator. These indicators summarize the energy use of the forest sector in its harvesting and manufacturing operations, and the resulting emissions of CO_2.

The forest sector consumes significant quantities of energy in harvesting, transporting and converting timber into products, particularly pulp and paper. As a result, the sector emits substantial quantities of CO_2 into the atmosphere. Most of these emissions come from burning fossil fuels, but certain industrial processes, such as lime production in kraft pulp mills, also result in emissions. Harvesting causes emissions because part of the harvested biomass (tree tops, branches, roots) is left to decompose, although much of the carbon associated with the harvest is stored in forest products. Additional emissions are produced indirectly through the sector's purchases of electricity and as a result of the transportation services it uses. Planting, seeding and natural regeneration processes contribute to carbon storage. Over time—up to 200 years—significant quantities of carbon may be stored.

In addition to emitting CO_2, burning fossil fuels and biomass results in emissions of methane (CH_4) and nitrous oxide (N_2O), two other greenhouse gases. The volume of these gases emitted by the sector is minute

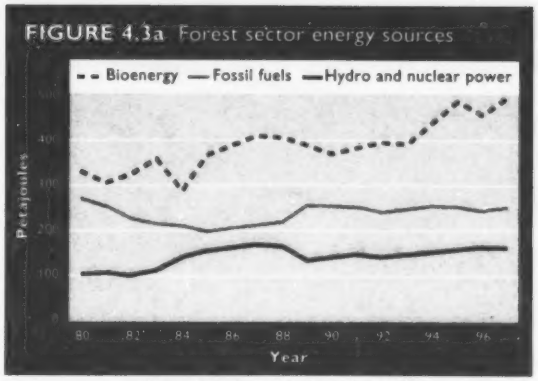
compared with emissions of CO_2 and they are not included in the estimates shown in this report. Only the CO_2 emissions from burning fossil fuels in harvesting and manufacturing operations and from the electricity purchased by the forest sector are discussed.

Fossil fuels used by the forest sector include coal, refined petroleum products, natural gas and biofuels in the form of wood residues and spent pulping liquor. Some electricity purchased by the sector is produced using fossil fuels such as natural gas, coal or coke. While electricity produced by using hydro power may be a source of methane emissions from large hydro reservoirs, the greenhouse gas emissions produced using hydro or nuclear power represent a small fraction of the total. In this report these values are assumed to be negligible.

Detailed data on the energy use of pulp and paper mills, lumber and planing mills and forestry operations are available from Statistics Canada for the period 1980 to 1997. The other segments of the forest sector, of which the most important in terms of energy use is the panelboard industry, account for only about 5% of the total energy use of the forest sector. Few data exist on energy use for other individual segments of the sector.

Figure 4.3a shows the proportion of each major energy source in the total energy use of the forest sector between 1980 and 1997. Fossil fuel use, including fossil fuels used in the electricity purchased by the sector, remained relatively constant in the 1990s. In 1997 it was 17% below 1980 levels. Direct fossil fuel use decreased even more. Purchases of fossil fuel electricity tripled, although they still accounted for only 20% of electricity purchases in 1997. The other 80% of the sector's electricity purchases came from hydro and nuclear power. The use of this emission-free electricity rose by 56% from 1980 to 1997, while biofuel use rose by 51%. As a result, bioenergy's share of total energy use rose from 47% to 55%, while the share of fossil fuels fell from 39% to 27%. Hydro and nuclear power rose from 15% to 18%.

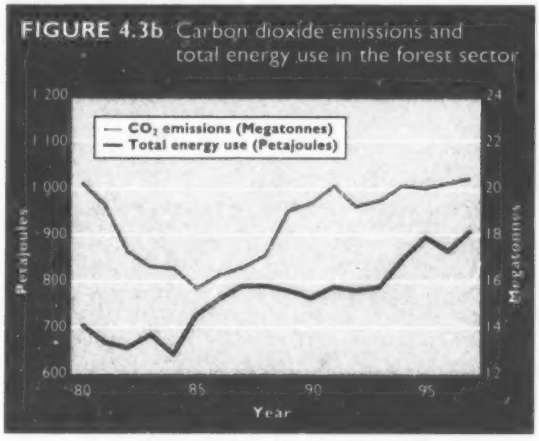
FIGURE 4.3a Forest sector energy sources



Source: based on data from Natural Resources Canada and Environment Canada 1980-1997

Overall, total energy use increased by 29% between 1980 and 1997, while fossil fuel CO_2 emissions fell by 4%, as shown in Figure 4.3b. During the same period, production of pulp, paper and lumber increased by more than 40%, suggesting significant improvements in energy efficiency. In addition, the forest sector (and in particular the pulp and paper industry) has undergone a major change from high carbon fuels (coal, refined petroleum) to low carbon fuels (natural gas) and renewable biofuels. Because of this, its share of total Canadian fossil fuel CO_2 emissions is now less than 5%, although it accounts for approximately 25% of industrial energy demand and about 10% of total Canadian energy demand.

FIGURE 4.3b Carbon dioxide emissions and total energy use in the forest sector



Source: based on data from Natural Resources Canada and Environment Canada 1980-1997

Figure 4.3c shows forest sector CO_2 emissions by fuel type. The fuel-switching effort of the sector is most clearly seen in the large decline in emissions from refined petroleum products and coal. The change from these carbon-intensive fuels to biofuels and natural gas has enabled the sector to limit emission increases while increasing energy use and output. Some of the decline in emissions from petroleum products and coal has been offset by increases in natural gas and fossil fuel electricity emissions.

While these trends are representative of the forest sector as a whole, the assessment would be improved by enhanced data on fossil fuel use and emissions of the panelboard industry and other segments of the forest sector and on emissions associated with the transportation services used by the sector.

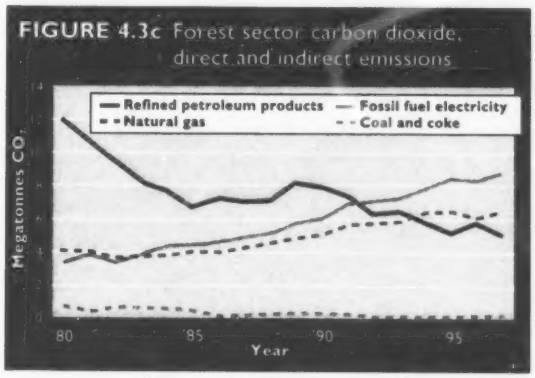


FIGURE 4.3c Forest sector carbon dioxide, direct and indirect emissions

Source: based on data from Natural Resources Canada and Environment Canada 1980-1997

ELEMENT 4.4
FOREST SECTOR POLICY FACTORS

ELEMENT OVERVIEW

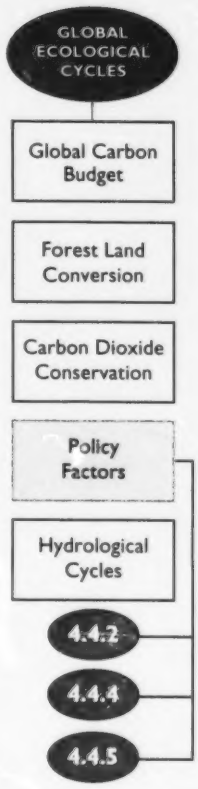
Canada's progress toward the conservation and sustainable development of its forests can be measured in part by its involvement in international climate change activities, as well as domestic initiatives in support of international efforts and obligations. Equally important are the appropriateness of Canada's collective policies and the manner in which its legal and regulatory frameworks influence such progress.

Sustainable forest management calls for a flexible and balanced integration of all factors of which it is composed. This approach necessitates that federal and provincial governments continually re-examine and adjust their policies, legislation, guidelines, standards, rules and manuals for forest managers. Element 4.4 provides a measure of governments' discernable commitments, through their laws, regulations and international activities, to ensuring the sustainability of the forest resource.

Canada is a signatory to the *United Nations Framework Convention on Climate Change* (UNFCC), which was adopted in 1992 at the Rio Earth Summit. Its ultimate objective is the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic (human-induced) interference with the climate system." It also states that countries shall seek to protect and enhance their greenhouse gas sinks and reservoirs. Canadian decision-makers and scientists continue to work with stakeholders to ensure that Canada is in a position to meet its commitments to this convention and the subsequent *Kyoto Protocol* (Indicator 4.4.2).

Ensuring that the nation's forests are managed sustainably requires a collaborative effort. Canada is a signatory to important international conventions on sustainable resource management, and the provinces, territories and federal government are all working together to ensure that national commitments are met. Comprehensive and up-to-date information on forest resources are required to respond to these commitments.

A forest inventory (Indicator 4.4.4) is a survey of a forested area to determine a number of its characteristics. Provincial and territorial forest management agencies employ various inventory systems in managing their forests. Forest inventories in Canada continue to evolve to address a full range of values related to sustainable management as more non-timber attributes are being added to successive cycles of inventory. Inventories are also being reformulated in order to provide national data on sustainable forests and changes to the resource over time.



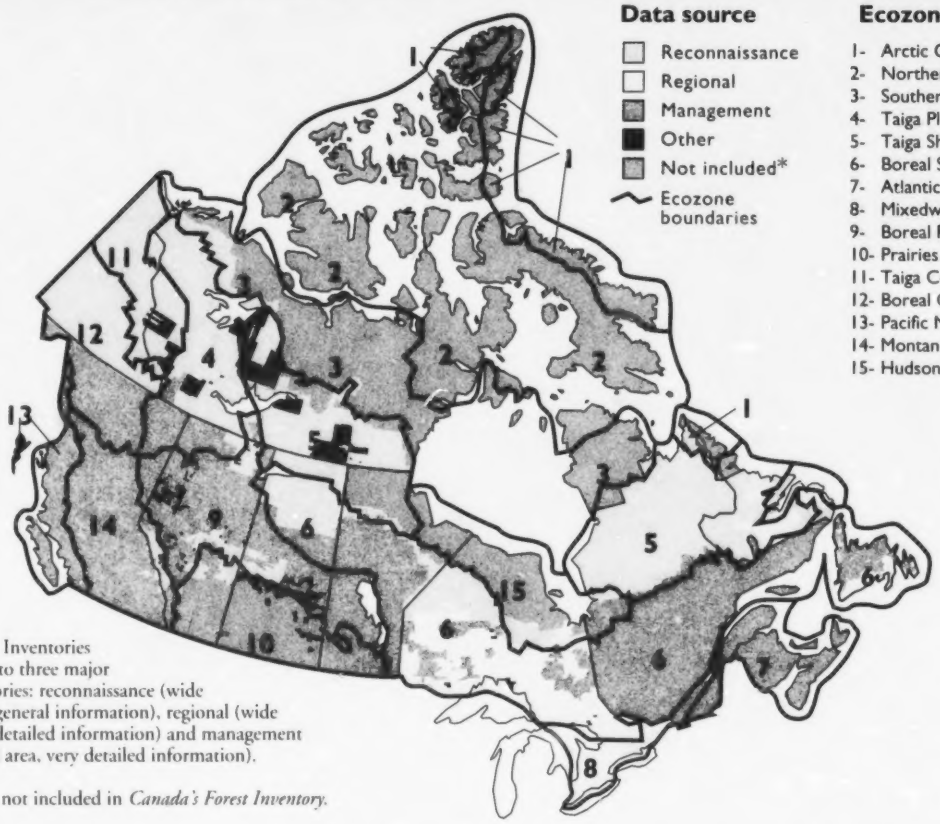
Across Canada, new forest laws, stricter enforcement of previously informal policies and guidelines, and the adoption of provincial criteria and indicators demonstrate that efforts are being made by the provinces and territories to achieve sustainable forest management (Indicator 4.4.5). A number of provinces have passed legislation based on the principles of sustainability, and government agencies across the country have adopted a consultative approach to forest management and policy development. All levels of government have committed to a national forest strategy and are working to incorporate its goals into their legislation, regulations and practices. In many cases, this has included the development of sets of criteria and indicators at provincial or local levels.

INDICATOR REPORTS

4.4.2 PARTICIPATION IN THE CLIMATE CHANGE CONVENTIONS

In December 1997, the parties to the UNFCC adopted the *Kyoto Protocol* (UNFCC 1997) to limit emissions of six greenhouse gases (ghg). Once the Protocol enters into force, the Annex 1 (industrialized) countries will have to reduce their average annual ghg emissions between 2008 and 2012 by 5% from the 1990 level.

FIGURE 4.4a Forest inventory coverage by data source



Source: Canadian Council of Forest Ministers 1997

Canada accepted a target of 6% below its 1990 emissions level. The Protocol will come into force after it has been ratified by at least 55 parties to the convention, including developed countries representing at least 55% of the total 1990 ghg emissions from this group.

In April 1998, the federal and provincial/territorial Ministers of Energy and Environment agreed on a process for developing a national implementation strategy on climate change that would help determine the costs and impacts of reaching Canada's *Kyoto Protocol* target. Among the sixteen tables established as part of this process were the Forest Sector Table and the Sinks Table.

The Forest Sector Table comprised experts from a diverse array of stakeholder groups, including government, the forest industry, environmental groups, organized labour, research organizations, academia, Aboriginal groups and forest-dependent communities. As part of its mandate, it examined the potential for the forest sector to help reduce Canada's ghg emissions through fuel-switching and energy efficiency (Indicator 4.3.3). Options were analyzed in terms of their costs and mitigation potential, as well as other considerations such as implications for competitiveness, environmental and health impacts, and employment.

The Sinks Table included experts in forest, agricultural and wetland carbon sinks and sources. In conjunction with the Forest Sector Table, it looked at ways to enhance forest carbon sinks and reduce forest carbon sources. The two Tables also considered additional activities that could be added to the Protocol to enhance the impact of carbon sinks.

A series of options was recommended by the Tables in their final *Options Reports*. These are currently being reviewed by federal, provincial and territorial governments for inclusion in the *National Implementation Strategy* and considered in relation to options suggested by other Tables. Work on the Strategy will continue throughout 2000.

Canada has been actively engaged in meetings to negotiate the definitions, interpretations and rules associated with carbon sequestering, or sinks, in the *Kyoto Protocol*. Resolution of these issues is not expected until the sixth Conference of the Parties, scheduled for late 2000.

Canada is also involved in the work of the Intergovernmental Panel on Climate Change (IPCC). Canadian scientists are participating in the preparation of the *Third Assessment Report*, scheduled for completion in 2000. As well, Canadian scientists collaborated on the IPCC *Special Report on Land Use, Land Use Change and Forestry*, which was released in May 2000 and was prepared to assist negotiators as they work to clarify the related sections of the *Kyoto Protocol*.

4.4.4 EXISTENCE OF FOREST INVENTORIES

A forest inventory may be defined as a survey of an area to determine the volume, location, extent, condition, composition and structure of the forest resource. Provincial and territorial forest management agencies employ a number of inventory systems, from reconnaissance (an exploratory inventory for strategic purposes) to operational (a detailed inventory of a specific area for operational harvest planning), to satisfy the needs of forest management (Figure 4.4a).

Covering most of the inventoried area in Canada, the management inventory is the most prevalent and important inventory system. It consists of complete area coverage, land cover mapping derived from aerial photography, and estimates of wood volume, biomass

TABLE 4.4a Characteristics of provincial/territorial forest management inventories*

Province/ Territory***	Inventory Areas	Inventory Cycle			Mapping		Sample Plot Cycle	
	Million hectares	Type	Number Completed	Period (years)	Scale	Update Schedule	Temporary	Permanent**
NF	10.16	Continual	4	10	1:12 500	4 year		Y(4)
NS	5.31	Continual	3	10	1:10 000	3 year	Y	Y(5)
PE	0.58	Periodic	3	10	1:10 000	periodic	Y	Y(3)
NB	7.11	Continual	5	10	1:12 500	annual	Y	Y(3&5)
QC		Continual	3	10	1:20 000	5 year	Y	Y
ON	61.45	Continual	3	20	1:10 000 1:20 000	5 year	Y	
MB	41.98	Continual	3	10-25	1:15 840		Y	Y(3&5)
SK	15.88	Continual	4	15	1:12 500			
AB	39.00	Periodic	4	15	1:15 000 1:20 000			
BC	93.43	Continual	5	10	1:20 000	2 year	Y	Y
YK								
NT	4.90	Continual	1	15-20	1:20 000		Y	Y(5)

* Characteristics for MB, SK and BC have been extracted from Leckie and Gillis, 1995.
** Numbers in parentheses indicate remeasurement periods in years.
***NF: Newfoundland and Labrador, NS: Nova Scotia, PE: Prince Edward Island, NB: New Brunswick, QC: Quebec, ON: Ontario, MB: Manitoba, SK: Saskatchewan, AB: Alberta, YK: Yukon, NT: Northwest Territories.

Sources: Natural Resources Canada—Canadian Forest Service 1998, Lowe et al. 1996

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YK								
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Sources: Natural Resources Canada—Canadian Forest Service 1998, Lowe et al. 1996

and other values from field samples. The data are used to support land-use planning decisions and to address regional, provincial/territorial and national reporting requirements. Management inventories are conducted on a cyclical basis, with cycles ranging from 10 to 25 years. Most provinces have conducted at least three cycles of inventory. Each successive cycle incorporates broader area coverage, improvements in standards and procedures, and additional attributes to reflect changing demands for information. Characteristics of provincial management inventories are provided in Table 4.4a.

Aerial photography provides forest cover maps that are up dated on a regular basis to capture changes to the extent, structure, health and productivity of the forests resulting from natural and human intervention. Ground sampling programs are conducted to provide additional attributes not readily available from aerial photography. Temporary sample plots are used to report on a wide range of attributes including trees, ecology, soils and wildlife. Permanent sample plots, which have remeasurement periods ranging from three to five years, are used to monitor forest growth and yield.

Canada also compiles a national forest inventory approximately every five years by aggregating existing management inventories. The national inventory is stored in a relational database management system and a geographic information system (GIS) that permit the mapping of the distribution and structure of the major forested areas. The current version of the national forest inventory does not reflect the present state of the forests. It cannot be used as a satisfactory baseline to monitor change because it lacks information on the nature and rate of changes to the resource and is compiled from inventories of different ages.

Forest inventories continue to evolve to address a full range of values related to sustainable management. More non-timber attributes are being added to successive cycles of inventory. Terms such as "productive forest" are disappearing in favour of non-cultural descriptions of the land base (e.g., treed versus non-treed).

4.4.5 EXISTENCE OF LAWS AND REGULATIONS ON FOREST LAND MANAGEMENT

The *Constitution Act* of 1867 assigns exclusive responsibility for forest resources to provincial governments. Section 92A of the Act states that the provincial legislature may exclusively make laws in relation to ". . . development, conservation and management of non-renewable and forestry resources in the province, including laws in relation to the rate of primary production therefrom." Provinces and territories now manage 71% of Canada's forests, while 23% is under federal and territorial jurisdiction and the balance is privately owned.

The provincial, territorial and federal governments share responsibilities in the areas of science and technology, industrial and regional development and the environment. Responsibility for international relations and trade and federal and Aboriginal land resides with the federal government. There are many common interests that are dealt with cooperatively through the Canadian Council of Forest Ministers.

The legal framework for forest management in Canada is composed of a series of instruments ranging from legislation to informal guidelines. **Forest legislation** (statute) defines broad government objectives in forest use and management and prescribes the manner in which rights to forest resources may be transferred to private parties, the responsibilities of government officials, and fiscal and managerial arrangements for the forests. Forest acts or statutes can only be amended by the relevant provincial, territorial or federal legislature. **Regulations** define statutory provisions and provide administrative means for implementation. Many of the rules of forest management are detailed in regulations, which have the full force of the law. **Common law** complements forest legislation and is based on historical cases and court decisions. The rules under which forests are used and managed may take the form of **guidelines, manuals, standards,** etc. which are not enacted as regulations but

are administered by the responsible forest authority. Although not having the force of law, these informal rules provide direction to forest managers in their daily operations. There has been a recent trend toward formally enacting guidelines as regulations. Once incorporated into operating permits and certificates of managed land, they are enforced by law.

Forest tenure arrangements are provincial policy frameworks that set out the conditions for private parties to operate on public lands. A tenure is defined as a right or interest granted by the government to harvest timber on public lands. Tenures can be grouped into three main categories: long-term, area-based tenures; medium-term, volume leases; and short-term, quota-based tenures (Luckert and Salkie 1998, Ross 1995). Tenure conditions specify what tenure holders can and cannot do and are increasingly administered within land-use planning frameworks (see text box below).

Forest lands are also subject to environmental protection legislation that applies regardless of ownership. Under the federal *Fisheries Act* and various provincial statutes, introduction of any substance deleterious to fish or fish habitat is prohibited and subject to prosecution.

The codification in law and the stricter enforcement of forest policies and guidelines are indicative of the response of Canadian forest agencies to new social, economic and environmental imperatives. Government agencies across Canada have adopted the consultative approach to developing forest policy, routinely seeking public opinion and working closely with forest industries, Aboriginal groups and environmental organizations to incorporate recreational, social, wildlife and economic values into forest management planning and decision making.

New legislation based on the principles of sustainability has already been passed by three provinces: British Columbia (1994 *Forest Practices Code of British Columbia Act*); Ontario (1994 *Crown Forest Sustainability Act*); and Saskatchewan (1996 *Forest Resources Management Act*). In 1996, the Province of Quebec amended its *Forest Act* to reflect the same commitment. Currently, in Manitoba, permission is being sought to update the *Forest Act*. Table 4.4b outlines recent provincial and territorial forest legislation that reflects the principles and objectives of sustainable forest management.

Long-term area-based tenures, which account for the majority of timber harvesting agreements, allow integrated forest companies to harvest an annual allowable cut (Indicator 5.1.1) within a defined area of sufficient size to supply a wood processing facility. Agreements are usually for 20 to 25 years and can be renewed every 5 years provided the terms have been satisfied. The company is responsible for most aspects of forest management and must follow prescribed standards for harvesting (road construction, fire and pest management), regeneration (silviculture) and non-timber forest values (wildlife and habitat protection, Aboriginal hunting grounds and burial sites, unique ecological and cultural sites). The company's plans and field operations are monitored for compliance generally by provincial forest services.

Volume-based tenure agreements, usually for 10 to 15 years, provide rights for a given volume of timber that may be cut in various places within a forest management unit. Management responsibilities are generally less demanding than for long-term tenures. The government is often responsible for calculating allowable cut and forest renewal. Detailed regulations governing harvesting, regeneration and the maintenance of non-timber values are monitored for compliance.

Short-term tenures are generally for periods of less than five years and are not renewable. These tenures are held by small companies or private individuals to harvest various types of timber for purposes such as fuelwood or Christmas tree operations. There are usually no management responsibilities. The provincial government monitors harvesting practices to ensure compliance with regulations.

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Forest tenure arrangements are provincial policy frameworks that set out the conditions for private parties to operate on public lands. A tenure is defined as a right or interest granted by the government to harvest timber on public lands. Tenures can be grouped into three main categories: long-term, area-based tenures; medium-term, volume leases; and short-term, quota-based tenures (Luckert and Salkie 1998, Ross 1995). Tenure conditions specify what tenure holders can and cannot do and are increasingly administered within land-use planning frameworks (see text box below).

Forest lands are also subject to environmental protection legislation that applies regardless of ownership. Under the federal *Fisheries Act* and various provincial statutes, introduction of any substance deleterious to fish or fish habitat is prohibited and subject to prosecution.

The codification in law and the stricter enforcement of forest policies and guidelines are indicative of the response of Canadian forest agencies to new social, economic and environmental imperatives. Government agencies across Canada have adopted the consultative approach to developing forest policy, routinely seeking public opinion and working closely with forest industries, Aboriginal groups and environmental organizations to incorporate recreational, social, wildlife and economic values into forest management planning and decision making.

New legislation based on the principles of sustainability has already been passed by three provinces: British Columbia (1994 *Forest Practices Code of British Columbia Act*); Ontario (1994 *Crown Forest Sustainability Act*); and Saskatchewan (1996 *Forest Resources Management Act*). In 1996, the Province of Quebec amended its *Forest Act* to reflect the same commitment. Currently, in Manitoba, permission is being sought to update the *Forest Act*. Table 4.4b outlines recent provincial and territorial forest legislation that reflects the principles and objectives of sustainable forest management.

FOREST TENURES IN CANADA

Long-term area-based tenures, which [illegible] integrated forest companies to harvest an annual allowable cut [illegible] within a defined area of [illegible] and to supply a wood processing facility. Agreements are for 20 to 25 years and can be renewed every 5 years provided the terms have been met. The company is responsible for most aspects of forest management and must follow prescribed standards for harvesting (road construction, fire and pest management), regeneration (silviculture) and non-timber forest values (wildlife and habitat protection, Aboriginal hunting grounds and [illegible] sites, unique ecological and cultural sites). The company's plans and field operations are monitored for compliance periodically by provincial forest service [illegible].

Volume-based tenure agreements usually for 10 to 15 years provide rights for a given volume of timber that may be cut in various places within a forest [illegible]. Management responsibilities are generally less demanding than for long-term tenures. The government is often responsible for calculating allowable cut and forest renewal. Detailed regulations governing harvesting, regeneration and the maintenance of non-timber values are monitored for compliance.

Short-term tenures are generally for periods of less than five years and are not renewable. These tenures are held by small companies or private individuals to harvest various types of timber (or products such as fuelwood or Christmas trees) for specific [illegible]. There are usually no management responsibilities. The provincial government monitors harvesting practices to ensure compliance with regulations.

TABLE 4.4b Recent forest legislation supporting sustainable forest management

Province/Territory	Year	Act	Description of Act
Alberta	1999	Water Act, S.A. 1999, c.W-3.5	Supports and promotes the conservation and management of water.
	1999	Regulated Forestry Profession Act, S.A. 1999, c.R-12.6	Enhances the quality of forest services in the province, by improving the regulation of forestry professionals.
British Columbia	1997	The Ministry of Forests Act, R.S.B.C. 1996, c.300 *Consolidated to April 21, 1997*	Establishes a Forest Service to ensure integrated use of forest and range resources.
	1997	British Columbia Forest Renewal Act, R.S.B.C. 1996, c.160 *Consolidated to December 18, 1997*	Redistributes a portion of stumpage revenues on a regionally equitable basis for forest improvement purposes.
	1998	Forest Practices Code of British Columbia Act, R.S.B.C. 1996, c.159 *Consolidated to December 18, 1998*	Enshrines principles of sustainable use of the forests; sets out principles and objectives for the use and management of provincial forests and wilderness areas; establishes operational planning requirements; and codifies a variety of forest practices and standards.
	1998	Forest Land Reserve Act, R.S.B.C. 1996, c.158 *Consolidated to September 23, 1998*	Aims at protecting the productive forest land base by creating a forest land reserve and restricting the uses of that land.
	1998	Forest Act, R.S.B.C. 1996, c.157 *Consolidated September 23, 1998*	Provides for disposition of timber on public land by the government under tenure agreements. The Act requires inventory of forests and assessment of their ability to grow trees and supply wildlife, recreation and forage for livestock. The Act accommodates forest uses, such as the manufacture of timber, and contains provisions for administering the harvest.
Manitoba	1990	The Forest Act, C.C.S.M. 1965, c.F150	Departmental request presented to legislative committee (1999) to develop a new and updated *Forest Act* and associated regulations. Provincial Forest Practice Committee established to determine minimum provincial operating standards.
New Brunswick	1982	Crown Lands and Forests Act, S.N.B. 1980, c.C-38	Provides for the development, utilization, protection and integrated management of the resources of Crown lands, including access to and travel on those lands; harvest and renewal of timber resources; habitat for the maintenance of fish and wildlife populations; and forest recreation and rehabilitation.
	1998	Conservation Easements Act, S.N.B. 1998, c.16	Provides for the granting of conservation easements for: the conservation of ecologically sensitive land; the protection, enhancement or restoration of natural ecosystems; the protection or restoration of wildlife habitat or wildlife; the conservation of habitat of rare or endangered plant or animal species; the conservation or protection of soil, air, land or water; the conservation of significant biological, morphological, geological or palaeontological features; the conservation of culturally, archaeologically or scenically important places; and the protection or use of land for recreational or public education purposes.

Newfoundland and Labrador	1990	The Forestry Act, S.N. 1990, c. 58.	Establishes a Forest Service. Requires preparation of a timber resource analysis and forest management strategy and the management of forest management districts in accordance with the principles of sustained yield management. Requires licensees to enter into Forest Management Agreements and prepare a forest management plan. The Act also provides for timber sale agreements and cutting permits, mill licences, forest protection, forest roads and timber scaling.
	1990	Revised Twenty-Year Forestry Development Plan, R.S.N. (1990-2010)	Reflects the comprehensive assessment of the province's timber resource completed in 1989 and includes a detailed analysis of the sustainable timber supply in relation to the demand. Significant to this plan is the treatment of forest ecosystem management and the need to shift from a single-resource management regime to one that considers all values.
	1996	Revised Twenty-Year Forestry Development Plan, R.S.N. (1996-2015).	Addresses more specifically the stages for the strategic development and protection of natural ecosystems by ensuring that management activities are carried out in a sustainable manner through adaptive management.
Northwest Territories	1988	Forest Management Act, R.S.N.W.T. 1988, c. F-9	Provides control, management and administration with respect to research, harvest and management of forests.
	1988	Forest Protection Act, R.S.N.W.T. 1988, c.F-10	Provides control, management and administration with respect to forest fire control.
	1990	Forest Management Regulations R.R.N.W.T. 1990, c.F-14	Provide control, management and administration with respect to research, harvest and management of forests.
Nova Scotia	1998	Wilderness Areas Protection Act, S.N.S.1998, c.11	Designates and allows for protection of 31 new areas of public land as representative examples of distinct natural landscapes and ecosystems in Nova Scotia. Requires public consultation in the preparation of a management plan for each area.
	1998	Regulations under the Forests Act, S.N.S. 1986, C.10	Require that certain buyers and exporters of wood submit statistical returns concerning the origin and uses of all wood acquired.
	1998	Amendments to the Forests Act, S.N.S. 1986, c.10	Enable agreements with buyers of forest products for more effective management of forest lands; ensure that the principle of sustainable forest management forms the basis of all forest management programs in the province; introduce mandatory standards to protect wildlife habitats, watercourses, wetlands and other significant resources in both private and public lands; require a person carrying out industrial forest harvesting operations on privately owned lands to provide certain information; regulate wood acquisition; establish a Sustainable Forestry Fund; permit conservation officers to inspect forestry or harvest operations and to issue certain Orders; and expand the enforcement powers of the Department.
Ontario	1994	Crown Forest Sustainability Act, S.O. 1994, c.25	Replaces the Crown Timber Act. Provides for the sustainability of public forests in accordance with the objective to manage the forests to meet the social, economic, and environmental needs of present and future generations. Sustainability includes the conservation of large, healthy and diverse forests and the maintenance of forest health through practices which emulate natural activities

			and avoid adverse effects. The Act provides for agreements with First Nations regarding sharing of some Ministerial authority and planning and requires the establishment of local citizens' committees to advise on management plans. Provides for the establishment of a Forest Renewal Trust fund and a Forestry Futures Trust fund.
	1998	Forestry Act, R.R.O. 1990, Reg.458	Under Bill 25, the *Red Tape Reduction Act* became law. It consolidates all of the following into the *Forestry Act: Trees Act, Forest Tree Pest Control Act*, and *Woodlands Improvement Act.*
Prince Edward Island	1988	Forest Management Act, S.P.E.I. 1988, c.27	Requires the preparation of a Forest Policy for public review and a state of the forest report every ten years. Includes provisions for management plans for public and private lands.
Quebec	1996	Amendments to the Forest Act, S.Q. 1986, c.108	Specify the criteria for sustainable forest management and create a fund for R&D, plantations and forest inventories from industry fees.
Saskatchewan	1999	Forest Resources Management Act and Regulations, S.S	Address conservation, management and development. Introduce a new tenure system. Require state of the forest reports, the establishment of a Provincial Forest Policy Advisory Committee as well as local forest management committees, and the preparation of integrated forest land use plans for each management unit. Provide a legal framework for public participation in planning processes and in the development of specific standards and guidelines appropriate to the maintenance of the different forest ecosystem sites.
Yukon	1950	Territorial Lands Act	Provides for the federal government to make regulations for managing the harvesting of timber in the Yukon. Major revisions to the Yukon timber regulations are pending OIC approval in 2000.

ELEMENT 4.5 CONTRIBUTIONS TO HYDROLOGICAL CYCLES

ELEMENT OVERVIEW

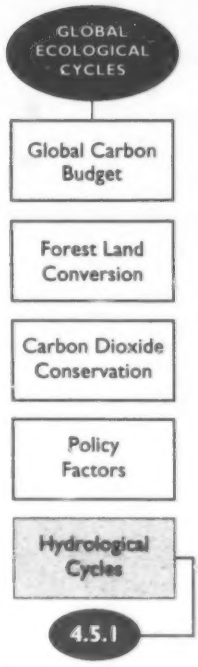
Fresh water is vitally important to all terrestrial plants, animals and microorganisms. Hydrological cycles are a critical component of the functioning of the Earth's biosphere. They involve the movement of water: from the atmosphere to the Earth's surface in the form of precipitation; from soils to streams to lakes to the ocean; and from the soil to plants to the atmosphere in the form of evapotranspiration. Because of their vast area, Canada's forests play a major role in global hydrological cycles.

The storage of water in the lakes and open water bodies that occupy almost 80 million hectares of Canada's surface area, and represent about 15% of the total forest area, comprises an important part of the hydrological cycle. Over half of this water area is contained within the Boreal Shield and Taiga Shield ecozones, which cover more than half of Canada's forest area. Canada's lakes and rivers are believed to represent one quarter of the world's freshwater supply.

Changes in forest land cover and management influence the storage and movement of water and the timing of the various components of the hydrological cycle. In addition to regulating the water flow into streams and the atmosphere, forests also clean and filter the water.

The forest can regulate the flow of water into lakes and wetlands directly or by influencing stream and river flows. Consequently, sustainable forest management plays a crucial role in contributing to the regulation of the hydrological cycle. Management practices can have a significant impact on water storage and the magnitude and timing of run-off in forest areas. This in turn has implications for stream bank erosion, siltation and water quality. All of these have effects on wildlife and aquatic life as well as implications for industry, recreation and tourism, power generation, and drinking water supply.

INDICATOR REPORT



4.5.1 SURFACE AREA OF WATER WITHIN FORESTED AREAS

Canada's Forest Inventory 1994 (Lowe et al. 1996) provides data on the surface area of Canada covered by water for the treed area of the country only, and does not include the Prairie agricultural zone in Saskatchewan and Alberta, nor the areas north of the tree line in the Northwest Territories, Manitoba, Ontario, Quebec and Labrador. The inventory data are collected at a scale of 1:10 000 and 1:20 000, allowing for the inclusion of water bodies of 0.01 to 0.02 hectare in size. The current report outlines the estimated surface area of water in the various forested ecozones of Canada based on information from *Canada's Forest Inventory*.

Table 4.5a shows the area of fresh water as compared with total area of Canada's ecozones. Almost 8% of the total land area, or some 78.7 million hectares, are occupied by open freshwater surfaces. The combined Boreal (Plains, Shield and Cordillera) and Taiga (Plains, Shield and Cordillera) ecozones receive twice as much precipitation as they lose through evapotranspiration annually, and contain approximately 83% of the total surface fresh water in Canada.

Efforts are ongoing to determine the role and influence of forest land cover and management on the hydrological cycle. In western Canada, work is underway on four components of the hydrological cycle that would enhance future reports on this indicator: precipitation received; evapotranspiration (the release of water by the forest to the atmosphere); snowmelt (how the forest and forest characteristics affect the magnitude and timing of run-off in the spring); and total basin run-off (how forest characteristics and cover affect the annual quantity or yield of water).

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TABLE 4.5a Surface area of fresh water by ecozone

ECOZONE	TOTAL AREA (million ha)	FRESH WATER* (million ha)	%
Arctic Cordillera	25.06	0.07	0.28
Northern Arctic	151.06	N/A**	N/A
Southern Arctic	83.24	1.23	1.48
Taiga Plains	64.70	5.46	8.44
Taiga Sheild	136.64	20.62	15.09
Boreal Shield	194.64	29.38	15.09
Atlantic Maritime	20.38	2.53	12.41
Mixedwood Plains	19.44	6.27	32.25
Boreal Plains	73.78	8.65	11.72
Prairie	47.81	0.84	1.76
Taiga Cordillera	26.48	0.23	0.87
Boreal Cordillera	46.46	0.97	2.09
Pacific Maritime	21.90	0.40	1.83
Montane Cordillera	49.21	1.49	3.03
Hudson Plains	36.24	0.68	1.88
Canada	**997.04**	**78.70**	**7.89**

*The surface area of the Great Lakes is not included.
**N/A: Information not available.

Sources: Natural Resources Canada—Canadian Forest Service 1998, Lowe et al. 1996

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CRITERION 5

MULTIPLE BENEFITS TO SOCIETY

INTRODUCTION

5.1 Productive Capacity

- 5.1.1 Annual removal of forest products relative to the volume of removals determined to be sustainable
- 5.1.2 Distribution of, and changes in, the land base available for timber production
- 5.1.3 Animal population trends for selected species of economic importance
- 5.1.5 Availability of habitat for selected wildlife species of economic importance
- 5.1.4 Management and development expenditures

5.2 Competitiveness of Resource Industries

- 5.2.1 Net profitability
- 5.2.2 Trends in global market share
- 5.2.3 Trends in research and development expenditures in forest products and processing technologies
- 6.5.2 Investments in forest-based research and development and information

5.3 Contribution to the National Economy

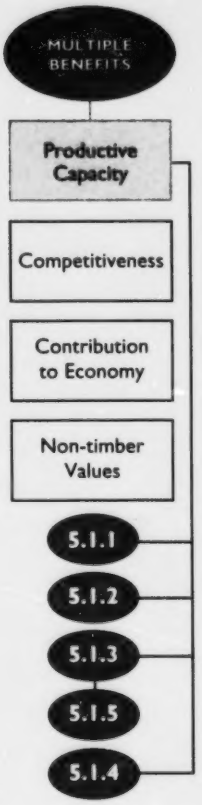
- 5.3.1 Contribution to gross domestic product (GDP) of timber and non-timber sectors of the forest economy
- 5.3.2 Total employment in all forest-related sectors

5.4 Non-timber Values

- 5.4.1 Availability and use of recreational opportunities
- 5.4.2 Total expenditures by individuals on activities related to non-timber use

INTRODUCTION

MULTIPLE BENEFITS OF FORESTS TO SOCIETY



Forests provide a multitude of benefits to society, including commercial wood products, commercial and non-market goods and services, environmental functions and preservation values. Sustainable development requires that Canada's forests maintain their ability to provide this array of benefits for future generations. Criterion 5 examines the economic value of a range of goods and services provided by forests and, where possible, measures the feasibility of their sustained production.

Element 5.1 *(Productive Capacity)* focuses on the capacity of the forest to support a flow of timber and non-timber benefits now and in the future by comparing annual rates of removal with quantities determined to be sustainable.

To ensure a continual flow of economic benefits to Canadians, a fair and competitive investment climate must be maintained within the forest sector. Element 5.2 *(Competitiveness of Resource Industries)* considers the ability of forest industries to maintain or expand the flow of economic benefits.

In addition to maximizing economic development, sustainability addresses the distribution of wealth. The forest generates wealth which flows to Canadians through the market economy, quantified in Element 5.3 (*Contribution to the National Economy*), and through a subsistence economy which involves in-kind income.

A wide range of non-timber values is associated with forests, including recreation, tourism, and existence and option values. Element 5.4 *(Non-timber Values)* considers the importance Canadians place on these non-timber goods and services and determines their availability.

ELEMENT 5.1 PRODUCTIVE CAPACITY

ELEMENT OVERVIEW

Productive capacity is the ability of the forest land base to provide a flow of benefits to society. This ability applies to both timber and non-timber resources. The productive capacity of resources must be conserved even as the flow of benefits is maintained. Productive capacity for timber is a reflection of annual average growth (Indicator 2.3.1) and the forest land available for timber harvesting (Indicator 5.1.2).

In addition to timber for wood products and fuel, forests provide habitat for an array of flora and fauna that are subsequently harvested and used by humans (Indicators 5.1.1 and 5.1.3, 5.1.5). These products may be food (mushrooms, berries, herbs and edible plants, fish and game), clothing (animal pelts) or botanical medicines and craft materials. The supply of forest products is influenced by various factors, including disturbances such as forest fires, insect defoliation, disease, harvesting, climate change, over-consumption and unregulated or illegal use. The supply and production of timber and non-timber products are interrelated. For example, timber harvesting and renewal practices can affect the amount and distribution of various elements of moose habitat, including winter cover, travel corridors and calving and feeding areas. The design and implementation of these management practices can have positive or negative effects on moose habitat and resulting population

levels. To implement sustainable forest management practices, an in-depth understanding of the relationship between timber and non-timber resources is required.

The sustainability of the economic benefits from forests can be measured by comparing the annual harvested volumes with the permitted rate of harvest set by the appropriate regulatory agency. In the case of timber, the annual rate at which harvesting is permitted to occur on provincial or territorial public land is known as the annual allowable cut (AAC). An AAC is determined by the provincial forestry service for each forest management unit over which it exerts regulatory control. A national AAC can be estimated by adding the harvest potential of federal and private lands to total provincial and territorial AACs.

Methods for determining AAC are complex and vary significantly across Canada. Estimates are based on the extent of the forest land base, the growth rate of trees, losses due to fire, insects and diseases, accessibility, economic and environmental considerations, silvicultural investment, degree of protection and management objectives.

Between 1970 and 1997, the total harvest was consistently below the estimated national AAC. Both the hardwood and softwood harvests are increasing, but while the hardwood harvest remains well below the AAC, some areas have experienced softwood shortages.

Determining sustainable harvest levels for non-timber products is more problematic. There has been considerable progress in managing populations of forest-dependent species of economic importance in Canada (Indicator 5.1.3). This is demonstrated by the recovery of species such as beaver, fisher and elk from historic low numbers in the 20th century. These recoveries largely reflect the success of resource management agencies in regulating hunting and trapping. An additional factor, which is becoming increasingly important, is the combination of scientific knowledge of species habitat with landscape approaches to timber management and geographic information systems (GIS). This technique allows species habitat to be monitored, modelled and mapped through time. Some provinces can now provide detailed information on habitat availability for particular species. The conservation status, geographical distribution, abundance, population trends and factors affecting the abundance of selected Canadian mammals of economic importance are discussed in this element.

The productive capacity of the forest for important game and fur-bearing species is more difficult to measure, and only limited information is available on their population and harvest levels. Information on the number and economic value of species harvested for pelts, as well as on the harvesting of game species and the revenue generated through the sale of licences, is described. National data that measure the value of other non-timber resources extracted from the forest, such as those used in food, clothing or botanicals, are not available.

The nature of ownership influences how forest resources will be used and managed. Ninety-four percent of Canada's forest land is under public ownership. Canadians' increasing demands to conserve forests for non-timber uses are reducing the availability of public forest land for timber production (Indicator 5.1.2). Governments have set aside large tracts of managed productive forest land for protection as parks or reserves. As well, policies and guidelines have been established to regulate and control timber harvesting, and to ensure that other values are conserved. For example, logging is prohibited or restricted on buffer strips along waterways and on steep slopes. In many regions, forest cover must also be maintained for scenic value and wildlife habitat. The combined effect of these policies has been, and will continue to be, some local reductions in the area of public forest land available for managed timber production.

Effective forest management requires a sustained and adequate source of funding. Expenditures on forest management and development (Indicator 5.1.4) represent investments with the potential to maintain and increase the productive capacity of the land base and improve its economic accessibility. Expenditures are incurred in a number of areas, including silviculture, resource access, protection and general stewardship. The recent decrease in expenditures may in part be explained by lower fire protection costs and by silvicultural practices that emphasize natural regeneration of harvested areas as part of an ecosystem-based management regime.

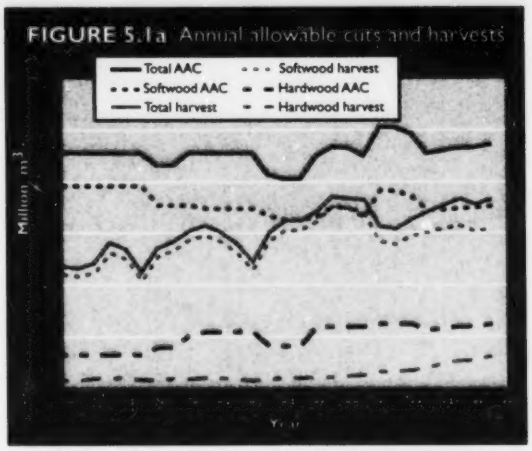
5.1.1 ANNUAL REMOVAL OF FOREST PRODUCTS RELATIVE TO THE VOLUME OF REMOVALS DETERMINED TO BE SUSTAINABLE

The level of harvest set by the provinces and territories for a defined time period is called the annual allowable cut (AAC). The AAC figures for Newfoundland and Labrador, Prince Edward Island, Nova Scotia, New Brunswick, Quebec and Manitoba include data from federal, provincial and private lands. A national AAC is estimated by adding the harvest potential of federal and private lands to total provincial and territorial AACs.

Canada's AAC has remained relatively stable over the past 27 years (Figure 5.1a). Fluctuations in the national AAC are mainly the result of changes in the provincial or territorial AACs rather than in federal or private harvest potential. A number of factors may influence the decision to reduce or increase the AAC for a particular area. For example, AACs may decline in response to a regulatory requirement for a reduction in the size of clearcuts or enlarged buffer strips, or in order to accommodate other land-use requirements such as protected areas, wildlife habitat and Aboriginal land claims. AACs may increase as a result of improved inventory information (e.g., growth and yield data), utilization (e.g., total tree utilization, sawmill yields) or as a result of silvicultural practices or social values.

Between 1970 and 1997, the total harvest was consistently below the national AAC (183 million cubic metres versus 236 million cubic metres in 1997). The softwood harvest has been increasing since 1970. While it is still below the national AAC, some local shortages have been reported, suggesting that the limits of sustainability may have been reached in those areas. The hardwood harvest has also shown a steady upward trend since the mid-1980s, but remains well below the national AAC.

FIGURE 5.1a Annual allowable cuts and harvests

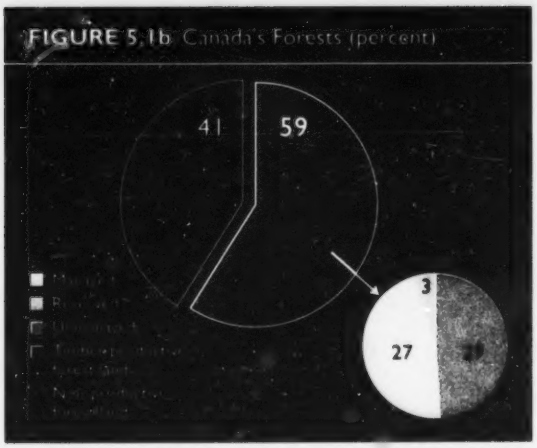


Sources: Natural Resources Canada—Canadian Forest Service 1998, Canadian Council of Forest Ministers 1998

5.1.2 DISTRIBUTION OF, AND CHANGES IN, THE LAND BASE AVAILABLE FOR TIMBER PRODUCTION

Canada's forest land is primarily under public ownership (provincial 71%, federal and territorial 23%). Fifty-nine percent of the more than 400 million hectares of forest land in Canada is considered to be capable of producing merchantable stands of timber within a reasonable length of time. Approximately half of this area is currently managed for timber production (Figure 5.1b). Approximately 1 million hectares are harvested annually (0.4% of Canada's productive forest).

A number of factors affect the land base available for timber production (Natural Resources Canada—Canadian Forest Service 1994). Policy changes may result in a withdrawal of forested areas for other uses, such as park land, while still maintaining the forest cover. Changes in economic factors, including product prices, advances in harvesting technology, and new highway construction, can influence whether it is economical to harvest a given area, and thus whether that area is part of the forest land base for the purpose of determining the allowable cut. Forest land may also be converted to non-forest land uses such as agriculture or urbanization, or may become unproductive due to catastrophic events such as landslides. These changes are discussed in the combined report on Indicators 3.1.2, 4.2.1, and 4.2.2.



Source: Natural Resources Canada—Canadian Forest Service 1999

The provincial and territorial governments, owning and managing most of the timber productive forest land in Canada, have enacted a range of policies and regulations to restrict the sale of public forest land and its conversion to other uses. For example, Manitoba does not permit the sale of its designated public forest land except for agricultural purposes. In British Columbia, the 1994 *Forest Land Reserve Act* restricts the removal of designated land from forest production. Alberta's *Green Area Policy* (in effect since 1948) states that public forest land will be managed primarily for forest production, watershed protection, recreation and other multiple uses. In Saskatchewan, disposal of public land requires an amendment to the *Forest Act*, while in Ontario, the *Public Lands Act* enables the Ministry of Natural Resources to regulate and control the sale of public land.

An important factor affecting the availability of public forest land for timber production is the increasing demand for non-timber uses. Large areas are being set aside and protected for parks, wilderness areas and reserves. For example, since 1990, close to 400 000 hectares formerly available for timber production have been placed under protected status in Alberta, increasing protected forest area in that province to over 1 million hectares. As of 1999, protected land in Manitoba reached 5.4 million hectares, or 8.3% of the province's area. Under Ontario's *Forest Accord*, which is an agreement among representatives of the forest industry, environmental groups and the Ontario Ministry of Natural Resources, a total of 378 new parks and protected areas are to be established. This will enlarge Ontario's protected area system by 2.4 million hectares, and bring the province's total protected forest area, in IUCN categories I to VI, to 5.1 million hectares.

5.1.3 ANIMAL POPULATION TRENDS FOR SELECTED SPECIES OF ECONOMIC IMPORTANCE

5.1.5 AVAILABILITY OF HABITAT FOR SELECTED WILDLIFE SPECIES OF ECONOMIC IMPORTANCE

Indicators 5.1.3 and 5.1.5 are reported together. Indicator 1.2.3 provided trends for selected animal species by province/territory. Some of those species (grizzly bear, woodland caribou, cougar) are considered to be of minor economic importance, and are not discussed here. Economically important mammal species are placed in two general categories—those that are primarily trapped for pelts, and those that are hunted for meat—with some overlap between the two.

The discussion that follows on population trends and estimated annual harvests is based on a recent study that evaluated the conservation status, geographical distribution, abundance, population trends and factors affecting the abundance of 20 selected animal species inhabiting Canada's forests (Alvo 1998).

Statistics Canada collects data on national sales of animal pelts by species. The economic value and number of pelts harvested for some of the species in the Alvo (1998) study are presented in Table 5.1a. Total value of pelts from beaver, bear, coyote, fisher, gray wolf, lynx, marten and red squirrel exceeded $20 million in 1997-1998. Table 5.1b provides information on the annual harvest of selected game species and the revenue generated by the sale of hunting licences. This information was supplied by Newfoundland and Labrador, Nova Scotia, New Brunswick, Quebec and Ontario. The revenue collected from the sale of combined hunting licences for moose, deer, bear and small game amounted to more than $32 million annually in the period 1993 to 1998.

Beavers were a mainstay of the fur trade for several centuries, and by 1900 were extirpated or vastly reduced over much of their global range. Since then, management programs have resulted in dramatic recoveries, and the annual harvest in North America is

now at an all-time high. Harvest levels are highly sensitive to price fluctuations because skinning beavers is labour-intensive and trappers will switch to other species (or other occupations) when prices fall.

The number of black bears harvested yearly is estimated to be 6% of the total population of approximately 400 000. The highest harvest level reported was in New Brunswick (11%). Black bear populations are stable in western Canada and stable to increasing in eastern Canada, and neither poaching nor hunting is perceived to be a major threat at this time. The black bear has been listed in Appendix III of the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES) (http://www.wcmc.org.uk/CITES/eng/index.shtml), mostly in an effort to reduce illegal trade in the gall bladders of related bear species that are globally at risk. This means that only bearskins can be legally exported from or imported to Canada.

The coyote, which is more commonly associated with grasslands than with forests, increased its range and numbers in eastern Canada during the 1900s and has become an important predator of white-tailed deer. Coyote populations are also on the rise in western Canada. Approximately 25 000 to 35 000 coyote are trapped annually in Alberta out of a total population of 150 000. In Saskatchewan, an estimated 15 000 individuals are taken out of a total population of roughly 140 000. In 1998, 50 249 coyote pelts were harvested in Canada, representing a value of $1 525 973.

Although the fisher originally inhabited the forests of Canada and the northern United States and extended south into the Appalachian, Sierra Nevada and Rocky mountains, it was extirpated from much of its historical range during the early 1900s. In addition to having a highly valuable pelt, fishers are easy to bait and trap. Concern that the species might not survive in the wild led to closed trapping seasons, reintroduction programs and habitat recovery efforts. A 1998 study estimated the Canadian fisher population at 66 500 individuals, compared with an estimated low of 10 000 in the 1930s.

Gray wolf populations in Canada have been stable for at least ten years. Although the wolf has been extirpated from southern and eastern areas, it still occupies 85% of its original range in Canada. In the late 1970s, 5 000 to 7 000 wolf pelts were harvested annually, but this fell to about 4 000 by 1984. Assuming that harvesting remains at this level, it represents less than 10% of the Canadian wolf population, and overall populations are more likely to be affected by trends in key prey species such as caribou. "Control hunting" to limit predation on livestock continues to reduce wolf populations in the southern portion of its range and may not be included in harvest statistics.

The lynx is highly dependent on the snowshoe hare for food, and the two species are locked in a predator-prey cycle. The overall population of lynx appears to be stable; however, careful regulation of trapping during low periods in the cycle is necessary (in order to counteract the trend of rising prices related to periodic scarcity). In 1997-1998, 6 840 lynx pelts were harvested, representing a value of $574 697.

The American marten has consistently been among the most valuable fur-bearing mammals since the beginning of the North American fur trade. It commands a high price, is easily trapped and pelted, and the pelts are easy to transport. Although the population appears to be stable, loss of mature forest habitat as a result of logging is a concern throughout Canada. As noted in Indicator 1.2.2, the Newfoundland population of martens is endangered and is the subject of intensive research and recovery efforts.

Although red squirrels are not highly valued by trappers and fur markets, they are harvested for both pelts and meat. The annual harvest varies widely in response to fur prices. In 1998, 146 075 squirrel pelts were harvested representing a value of $179 876.

About 4 000 elk are harvested each year by licensed hunters, and an unrecorded additional number by First Nations. Management of hunting pressure is important for this species. By the early 1900s, the elk population had declined to about 1% of its historic North American population level of 10 million, but has since rebounded to almost 1 million individuals (90% of which are found in the US). With hunting regulations in place, the main factor limiting elk populations in Canada is loss of habitat to agriculture. Forest practices have less impact on this species.

Moose are avidly sought by hunters, but populations of this species are also highly affected by severe winters with deep snow, predation by bears and wolves, collisions with vehicles, disease where their range overlaps with white tailed deer, and forestry practices.

A 1998 estimate of 960 000 moose in Canada considerably exceeds the 1970s estimate of 500 000, but it is not known whether this reflects a population increase or better reporting. In Quebec, moose populations are thought to have been as low as 12 000 in the early 1950s, but regulatory measures allowed a gradual increase to about 70 000 individuals in 1998. Annual harvest levels have also risen in that province from 7 000 in 1972 to 11 000 in 1996.

There are nearly 1.5 million white-tailed deer in Canada, and their numbers appear to be increasing. Timber harvesting, agricultural development, and mild winters have allowed this species to expand its range northward, and its popularity with hunters has led resource agencies to carefully manage hunting quotas and to identify and protect deer yards (winter cover) in timber management plans. National harvest figures are not available, but the 1996 harvest level in Quebec was estimated at 38 000, compared with a total population of 300 000. If numbers are not controlled, browsing by white-tailed deer can pose a serious challenge for forest management. As many as 150 000 deer live on Anticosti Island (Quebec) alone. The species was introduced there and has caused dramatic reductions in natural regeneration of forest cover since it has no natural predators and is only lightly hunted.

The Canadian population of mule deer is estimated at just under 500 000 animals, most of which (345 000) live in British Columbia, where three subspecies occur. The mule subspecies is the most widely distributed throughout the interior of the province. The Columbian black tail, or coast subspecies, is found on Vancouver Island, and the Sitka subspecies occurs on the northern coastal islands. Mule deer populations are declining in British Columbia and in Manitoba, where they have been displaced by white-tailed deer. The species is expanding northward into the Yukon in response to warmer winters. Unlike white-tailed deer, mule deer do not respond positively to urban and agricultural development, and are more vulnerable to hunting because they do not flee as far when disturbed. Because mule deer do not tolerate deep snow, logging of winter habitat is a problem for them, and has been associated with population declines on Vancouver Island. National harvest statistics are not available, but 17 000 individuals were harvested in Alberta in 1989 out of a total population of around 100 000.

The snowshoe hare is the most abundant forest-dwelling mammal hunted for meat in Canada. It is an important small game species and source of food in rural areas. It is characterized by cyclical variations in population levels, which may be as high as 50- to 100-fold. These variations are caused by its natural predators: red squirrels and arctic ground squirrels on juveniles; and owls, coyotes and lynx on adults. Harvesting by humans is not a major influence on population levels of this species. Wildlife experts in Quebec estimate that a harvest level of 30 to 40% would be sustainable, but only about 2 million snowshoe hares are taken annually in that province out of an average population of about 32 million.

TABLE 5.1a Economic value of harvested pelts for selected mammals in Canada

Mammal	Pelts harvested 1997-1998	Value ($)
Beaver	311 135	9 942 047
Bear*	2 083	140 524
Coyote	50 249	1 525 973
Fisher	20 036	903 789
Gray wolf	2 834	358 780
Lynx	6 840	574 697
Marten	160 700	6 470 915
Red squirrel	146 075	179 876

**Includes both black and brown bear.*

Source: Statistics Canada 1997-1998

TABLE 5.1b Annual harvest of economically important game species and revenue collected, 1993-1998

Game species	Hunting licences sold[a, b]	Annual harvest[a]	Revenue collected ($)[a]
Moose	279 935	42 283	12 161 977
Deer	445 287	114 183	12 662 004
Bear	43 149	10 823	2 713 041
Small game	381 615	435 480	5 083 760

[a]Values are annual means.
[b]Resident and non-resident data are combined.

Sources: Ministère de l'Environnement et faune—Direction des affaires institutionnels 1999, Newfoundland and Labrador Department of Forest Resources and Agrifoods 1998, Provincial records from Nova Scotia and New Brunswick for various years 1993-1998, Ontario Ministry of Natural Resources 1997

5.1.4 MANAGEMENT AND DEVELOPMENT EXPENDITURES

Figure 5.1c shows estimated total expenditures on forest management by activity for the period 1990 to 1997. These expenditures represent spending by both public agencies and the forest industry. In 1997, they totalled $2.3 billion.

Expenditures are incurred in a number of areas including silviculture (site preparation, planting, seeding, stand tending), resource access (road construction), protection (fire, pests), and general stewardship (inventory development, research, timber management, administration, integrated resource management, public information). The costs incurred for fire protection show the most discernable decline in recent years, as fewer forest fires have had to be suppressed. In 1997, there were 6 002 forest fires in Canada, the lowest number on record since the National Forestry Database started to record this information in 1970 (Indicator 2.1.3). These fires resulted in the destruction of 0.6 million hectares of forest land. Silviculture-related activities are also exhibiting a decline as more ecosystem-based management regimes, with emphasis on natural regeneration, are adopted. Trend data for wildlife and recreation management, parks programs, and the cost of protected areas were not collected because they are either not available or are aggregated with general stewardship data.

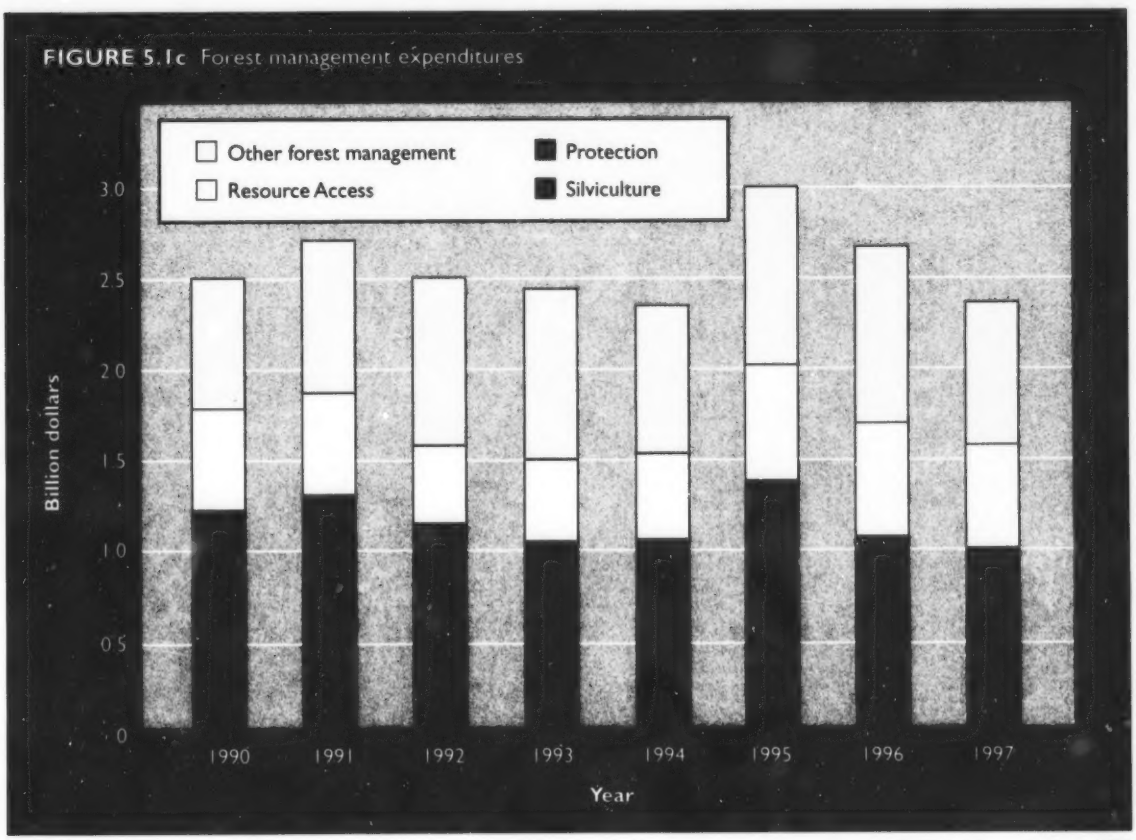


FIGURE 5.1c Forest management expenditures

Source: Canadian Council of Forest Ministers 1998

ELEMENT 5.2
COMPETITIVENESS OF RESOURCE INDUSTRIES

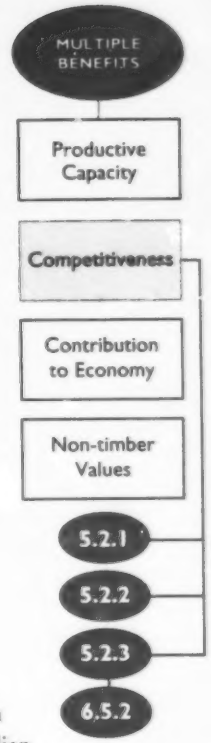
ELEMENT OVERVIEW

The competitiveness of an industry reflects its ability to efficiently combine inputs (labour, capital, raw materials) to produce and sell goods and services. A firm's competitiveness is affected by its productive efficiency as well as factors such as institutional, social, cultural, and regulatory policies. For example, tax laws, trade policies, social policies (labour force training, education, health, etc.) and environmental regulations all have an impact on an industry's competitiveness and overall performance.

Sustainable development recognizes the direct link between the environment and the economy. The ability of forest industries to provide jobs and incomes and pay corporate taxes to governments depends on their ability to earn profits, attract new investment, and access foreign markets. In addition, the relative efficiency and competitiveness of firms affects their ability to absorb the higher costs that may be associated with more environmentally sensitive resource development and industrial production.

Monitoring and measuring the profitability of the forest products sector (Indicator 5.2.1) is one means of assessing structural changes that may be occurring. Canadian firms must compete with foreign firms in export markets. For example, Canada currently accounts for 50% of the global trade in softwood lumber. The arrival of new producers of low-cost products in traditional markets may lower the price of final products, thereby affecting the profitability of Canadian firms. Declining profitability in a particular subsector may therefore be a symptom of structural changes occurring in the marketplace. In addition, the highly cyclical nature of some forestry subsectors may result in short-term financial losses or gains in a given year. It is the long-term profitability of the forest sector that continues to attract investors and entrepreneurs, and allows it to make an important contribution to Canada's economy.

Trends in the share of global markets (Indicator 5.2.2) provide a useful indication of the Canadian forest industry's ability to sell its products abroad. Canada currently accounts for more than 18% of the total value of global forest products trade. The ability to retain markets in other countries reflects the reputation of the Canadian forest sector for delivering consistently high quality products at competitive prices. For example, as a result of new technological advances, Canada has maintained a 33% share of the global pulp market.



Historically, Canada's rich endowment of natural resources has provided the forest sector with relatively low-cost raw materials, and therefore, a comparative advantage in the marketplace. With the increasing globalization of markets, however, developing countries with high-yield plantation forests are beginning to threaten Canada's position. Increasingly, the Canadian forest sector's ability to compete on the world scene depends on its ability to maintain low production costs and develop value-added products for specialty markets. Technological progress is important for achieving both of these objectives.

Trends in research and development (R&D) expenditures (Indicator 5.2.3) in forestry provide a useful preliminary indication of the ability of firms to innovate and thus maintain their competitiveness. R&D in forestry may involve scientific research carried out at universities, cooperative research institutes, private sector research facilities and mills; or forest resource-related science and technology sponsored by provincial, territorial and federal governments. Forest-based R&D includes applied research such as the development of improved seedlings or better production processes to reduce costs or meet higher environmental standards. Another focus of R&D is the development of new products and technological innovation, which may open new markets and confer competitive advantages.

To remain profitable and internationally competitive, the forest industry must position itself on the leading edge of innovation. In the complex and competitive

market of the new century, consumers expect high quality products at competitive prices, in addition to product differentiation, timely delivery and assurances of sustainable forest practices (Globerman et al. 1999). To effectively meet this challenge, the forest industry must continue to incorporate new technologies that increase the efficiency of natural resource use and development and that support the preservation of Canada's forest ecosystems for future generations.

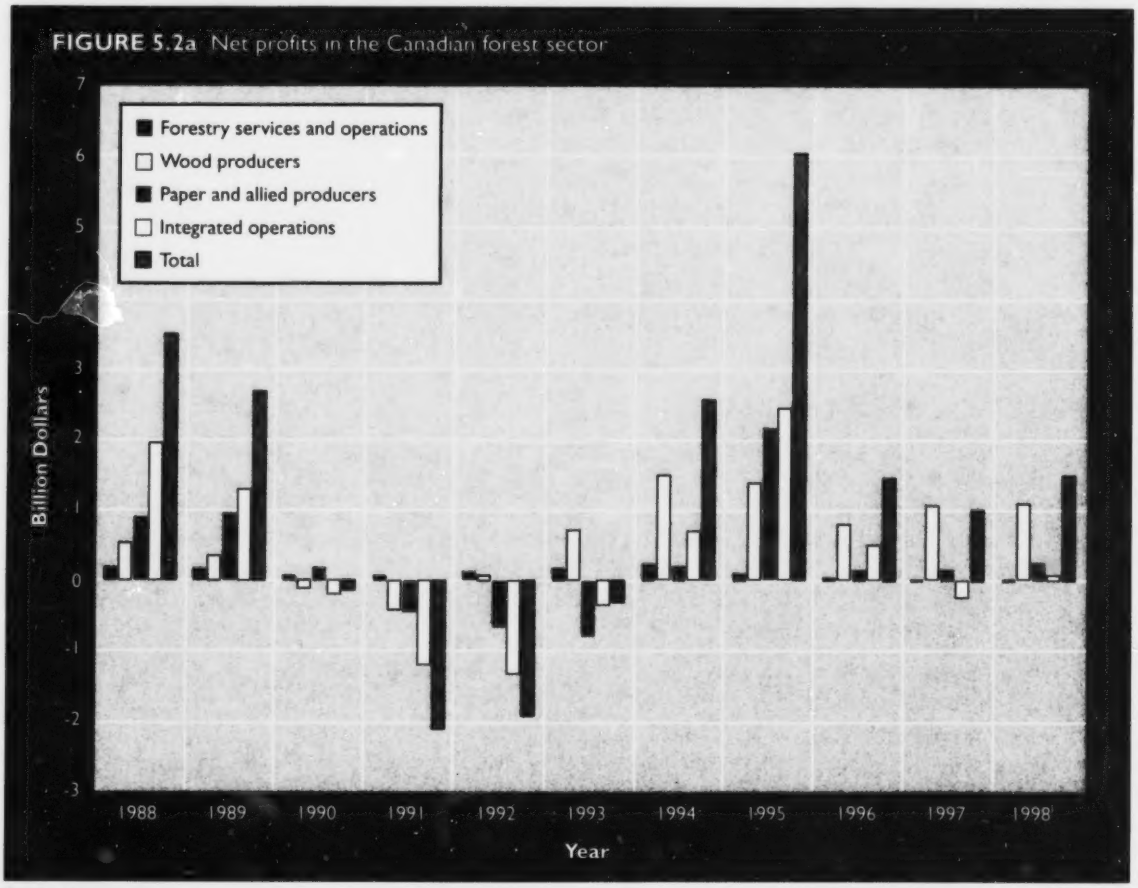
INDICATOR REPORTS

5.2.1 NET PROFITABILITY

In order to attract the capital required for expansion or infrastructure replacement, the forest sector must be in a position to earn profits at a level that is consistent with investment alternatives of equal risk. While sustained losses for individual firms over a number of years may result in corporate bankruptcies and the closure of unprofitable mills, trend data demonstrate that in many cases, existing firms or new investors will buy up failing companies, restructure them and inject new capital in an attempt to improve their profitability.

Figure 5.2a shows the profit performance (net income after taxes excluding extraordinary gains) of Canada's forest sector from 1988 to 1998. The figure demonstrates the cyclical nature of this indicator, with high levels of variability being experienced over short periods. Reduced profits and financial losses as experienced in the early 1990s are to be expected in the trough of the business cycle, and must be viewed in the context of the long-term profitability of the forest sector. A return to high profitability occurred in 1994, with sector profits in 1995 reaching a high of just over $6 billion. Lower demand for forest products and falling commodity prices once again reduced profits in 1996, 1997 and 1998.

FIGURE 5.2a Net profits in the Canadian forest sector



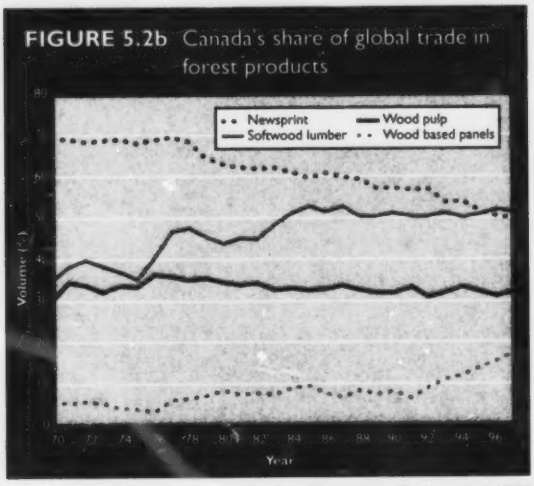
P=preliminary

Source: Statistics Canada 1988-1998

5.2.2 TRENDS IN GLOBAL MARKET SHARE

Figure 5.2b shows Canada's share of world exports by volume for various forest products. Canada currently accounts for 50% of the global trade in softwood lumber. The majority of Canada's exports are destined for the United States, while Japan and the European Union are also important customers.

FIGURE 5.2b Canada's share of global trade in forest products



Source: Food and Agriculture Organization 1999

The Canadian share of panel exports fluctuated between 4% and 9% from 1970 to 1992. Since 1992, Canada's share has risen steadily, reaching an all-time high of 17% in 1997. This can be attributed to increasing acceptance of products such as oriented strandboard and medium-density fibreboard manufactured from chips and other wood residues. Both particleboards and strandboards can be produced using hardwoods (such as aspen and other poplars) and secondary fibres from sawmills. The abundance of these low-cost raw materials has led to a significant increase in Canadian capacity for panel production in the last 20 years.

Although technological advances have enabled other countries to enter the global wood pulp market, Canada's share has remained near the 33% level since 1970. This is partly attributable to the introduction of new technologies and to the high quality of the long-fibre pulp produced from Canada's softwood trees.

In 1970, the Canadian share of world newsprint exports was 69%. By 1997, it had declined to 49%, due to increased global production capacity from the addition of new mills, especially in the US, which consumes the majority of Canada's newsprint exports.

5.2.3 TRENDS IN RESEARCH AND DEVELOPMENT EXPENDITURES IN FOREST PRODUCTS AND PROCESSING TECHNOLOGIES

6.5.2 INVESTMENTS IN FOREST-BASED RESEARCH AND DEVELOPMENT INFORMATION

Indicators 5.2.3 and 6.5.2 are combined and reported as one indicator.

The information available on forestry R&D activities is fragmented. Table 5.2a provides details on governments' forest-based research expenditures for the period 1990 to 1997. This includes the research budget of the Canadian Forest Service and provincial forest agencies, as well as research supported by the federal-provincial agreements in forestry. The information reveals that since 1994, government expenditures in forest-based research have declined by almost 40%.

Table 5.2b shows the industry-oriented R&D expenditures in forest products and processing technologies by subsector. Data from Canada's three principal industrial forest research institutes are included in the figures. The Forest Engineering

Table 5.2a Government expenditures in forest-based research

Year	1990	1991	1992	1993	1994	1995	1996	1997
Million dollars	112.8	126.1	137.1	137.3	151.7	102.7	98.9	91.1

Sources: National Forestry Database 1998, Natural Resources Canada—Canadian Forest Service 1998

Research Institute of Canada (FERIC), Forintek Canada Corp. and the Pulp and Paper Research Institute of Canada (PAPRICAN) conduct research and development in forest engineering, forest product development, and pulp and paper technology, respectively. In 1997, their combined R&D budgets totalled $65.4 million, or 44% of the total industrial forestry R&D expenditures.

TABLE 5.2b Industrial intramural forestry R&D* (million dollars)

	Logging industry and forestry services	Wood industries	Paper and allied industries	Total
1988	7	20	145	172
1989	8	18	151	177
1990	11	42	112	165
1991	11	19	98	128
1992	8	20	94	122
1993	9	23	102	134
1994	8	24	98	130
1995	9	24	101	134
1996[P]	10	25	110	145
1997[I]	9	26	113	148

P: preliminary I: spending intentions

*Includes the total budget of the three principal research institutes: FERIC, Forintek and PAPRICAN.

Source: Statistics Canada 1988-1997

Overall, industrial intramural R&D expenditures have increased since the early 1990s, but remain well below the level reached in the late 1980s. Expressed as a percentage of sales, R&D expenditures are currently at approximately 0.3% for the wood, and paper and allied industries, compared with rates of 0.5% and 0.4%, respectively, in 1989.

ELEMENT 5.3
CONTRIBUTION TO THE NATIONAL ECONOMY

ELEMENT OVERVIEW

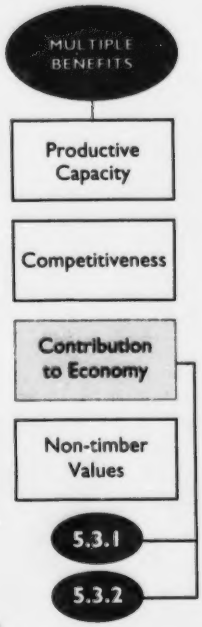
A wide range of goods is derived from forests, thus creating opportunities for the establishment of commercial enterprises. In addition to the traditional forest products sector, the forest land base supports a number of smaller industries such as outfitters, maple products producers and Christmas tree growers, as well as the increasing number of industries that cater to tourists. Revenues from forest-based tourism have doubled in the last 10 years. Revenues from non-timber commodities have also increased, with sales of maple products almost tripling since 1991.

The combination of all payments by forest-related industries for labour, capital, taxes, and resource rents represents the contribution of the sector to Canada's gross domestic product (GDP), and thus, the national economy (Indicator 5.3.1). In 1998, the forest industry's contribution to the Canadian GDP was $18.2 billion ($16.6 billion in constant 1992 dollars) representing approximately 2.3% of the total GDP for all industries.

An important dimension of sustainable development is the creation and maintenance of jobs and incomes (Indicator 5.3.2). Monitoring the employment performance of subsectors involved in both extractive and non-extractive commercial activities provides an indication of the forest sector's ability to contribute to Canadians' standard of living. Employment in the forest sector reached a 10-year high in 1998. The sustained employment in the industry is attributed to the growth of the value-added sector.

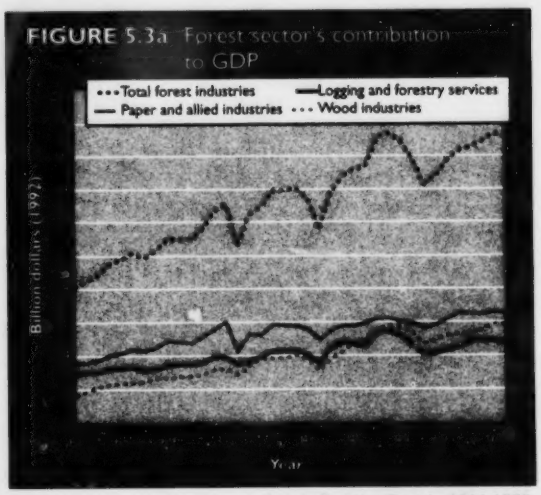
The wood industries and the paper and allied industries belong to the manufacturing sector. Here, higher labour productivity associated with new technology has led to increased wages. As a result, average salaries in the forest sector are generally higher than the average salary in the rest of the manufacturing sector.

INDICATOR REPORTS



5.3.1 CONTRIBUTION TO GROSS DOMESTIC PRODUCT (GDP) OF TIMBER AND NON-TIMBER SECTORS OF THE FOREST ECONOMY

The gross domestic product represents the value of goods and services produced annually within a country. The real GDP measures the value of the GDP in constant dollars to permit trend analysis without the influence of inflation. The forest sector is composed of three subsectors: logging and forestry services; wood industries; and paper and allied industries. Figure 5.3a shows the forest sector's contribution to Canadian real GDP between 1961 and 1998. These values are expressed in constant 1992 dollars. Despite noticeable declines in some years, each subsector's contribution has generally increased since 1961. In 1998, the Canadian forest sector contributed $16.6 billion (2.3%) to the total real GDP of $721 billion for all industries in Canada. Of this, the paper and allied industries made the largest contribution—$6.5 billion. Wood industries contributed $5.9 billion, and logging and forestry services, $4.2 billion.



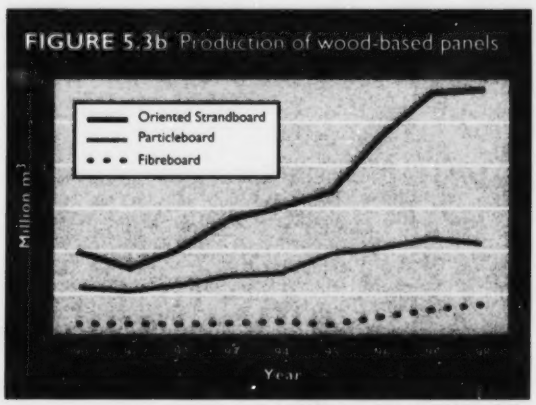
Source: Statistics Canada, 1961-1998.

TABLE 5.3a Trends in the number of establishments and in total revenues for service industries dependent on forests, 1986-1996

Year	Campgrounds and travel trailer parks		Outfitters, recreation and vacation camps	
	Number of establishments	Total revenue (million dollars)	Number of establishments	Total revenue (million dollars)
1986	2 003	229.9	1 439	232.0
1987	2 198	256.3	1 337	277.6
1988	2 387	279.1	1 618	299.9
1989	2 405	291.4	1 764	329.8
1990	2 454	310.1	1 826	347.1
1991	2 478	316.3	1 862	339.7
1992	2 573	336.9	1 927	347.5
1993	2 581	352.4	1 918	373.3
1994	2 585	370.3	2 050	431.1
1995	2 679	405.5	2 164	467.7
1996	2 640	421.2	2 178	488.4

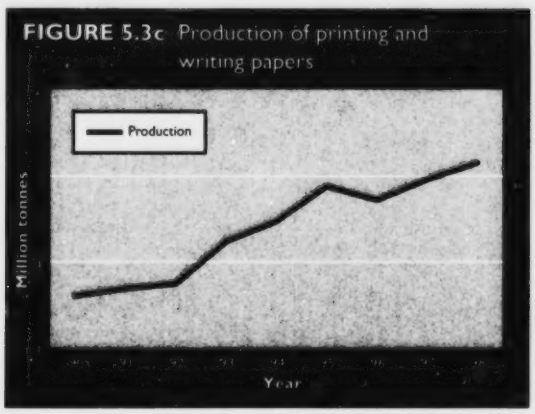
Source: Statistics Canada 1986-1996

In the wood products industries, lumber remains the most important segment, although production of value-added products such as oriented strandboard, particleboard and fibreboard has increased at a rapid pace in recent years (Figure 5.3b). Similarly, while production of newsprint and market pulp dominates the paper and allied industries, production of more process-intensive printing and writing papers increased by more than 43% between 1990 and 1998 (Figure 5.3c).



Source: Statistics Canada 1990-1998

Although patterns of production are changing, the Canadian forest sector remains heavily skewed towards traditional products whose prices have remained relatively low and cyclical. Therefore, despite the fact that the contribution to GDP by the forest sector has increased, the value per cubic metre of wood harvested has remained relatively constant. In addition, the relative importance of the forest sector tends to be understated when its contribution is measured in GDP because GDP does not include indirect impacts on other sectors of the economy.



Source: Canadian Pulp and Paper Association 1999

Detailed information on the contribution to Canadian GDP by the non-timber sector is not available. Information for the Christmas tree and maple products industry and for campgrounds and outfitters in the recreation sector is also reviewed in this report. Figure 5.3d shows that wholesale values (constant 1992 dollars) for maple products have been increasing, reaching $141 million in 1998. The wholesale value of Christmas trees produced in Canada decreased slightly from $53.5 million in 1990 to $51.5 million in 1997.

Table 5.3a illustrates trends in the number of establishments and the total value of receipts for two service-oriented sectors that depend on forests: campgrounds and travel trailer parks; and outfitters, recreation camps, and vacation camps. It also shows that total revenues increased steadily between 1986 and 1996.

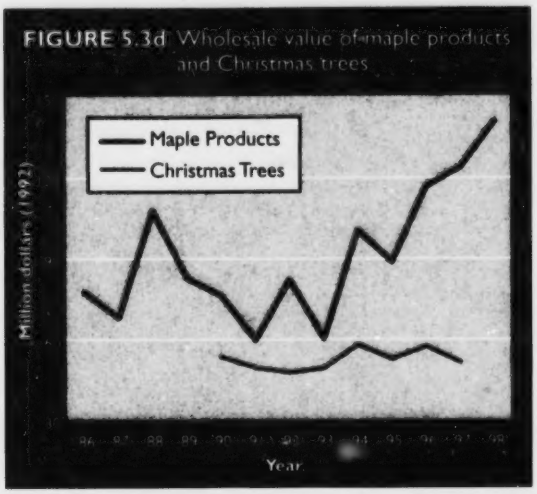


FIGURE 5.3d Wholesale value of maple products and Christmas trees

Source: Canadian Council of Forest Ministers 1998

5.3.2 TOTAL EMPLOYMENT IN ALL FOREST-RELATED SECTORS

Figure 5.3e shows that direct employment in the Canadian forest sector reached a record level of 384 000 in 1998, an increase of over 18 000 from the previous year. In 1998, the repercussions of the Asian crisis decreased employment in British Columbia, while increased employment opportunities were experienced in Ontario and Quebec as a result of economic growth in the United States. The wood industries sector, which includes sawmills, oriented strandboard mills and particleboard mills, accounted for the majority of the employment gains, adding 57 000 jobs since 1991—15 000 in 1998 alone.

A wide range of capital-intensive production technologies has been adopted by the forest industry over the last 20 years, thereby reducing the number of jobs created for each cubic metre of timber harvested. In the logging sector, mechanized harvesting machines have substantially improved labour productivity and reduced the number of individuals required to harvest a stand of trees. New highly automated, high-speed processing systems with optimal control scanners have dramatically decreased the number of sawmill employees required to produce a truckload of lumber. High-speed machines in some paper mills have reduced the amount of labour required to produce a tonne of newsprint. The net effect of these new technologies has been a general increase in the output of production per employee (Figure 5.3f).

The adoption of new technologies has allowed the forest sector to remain competitive in global markets and to increase production in some subsectors. Higher labour productivity associated with the new technology has led to increased wages. In 1997, the average annual income (in 1992 dollars) of workers in the paper and allied industries was $50 529. Employees in the logging and wood industries earned $40 311 and $36 152, respectively, while the average income of employees in other Canadian manufacturing industries was $38 599. Figure 5.3g compares the average annual real income of forest sector employees with that of workers in the entire manufacturing sector over the period 1970 to 1997.

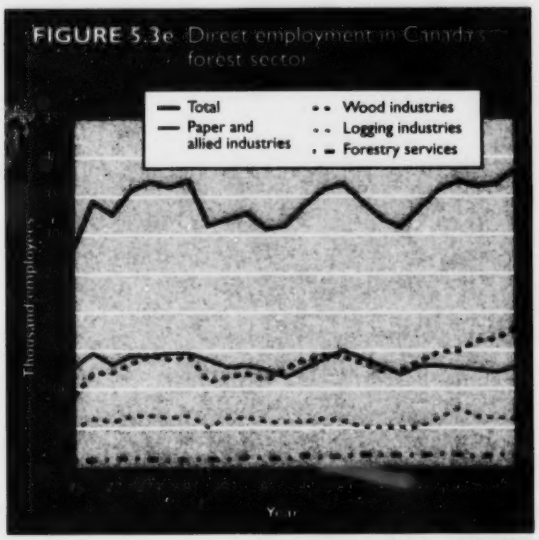
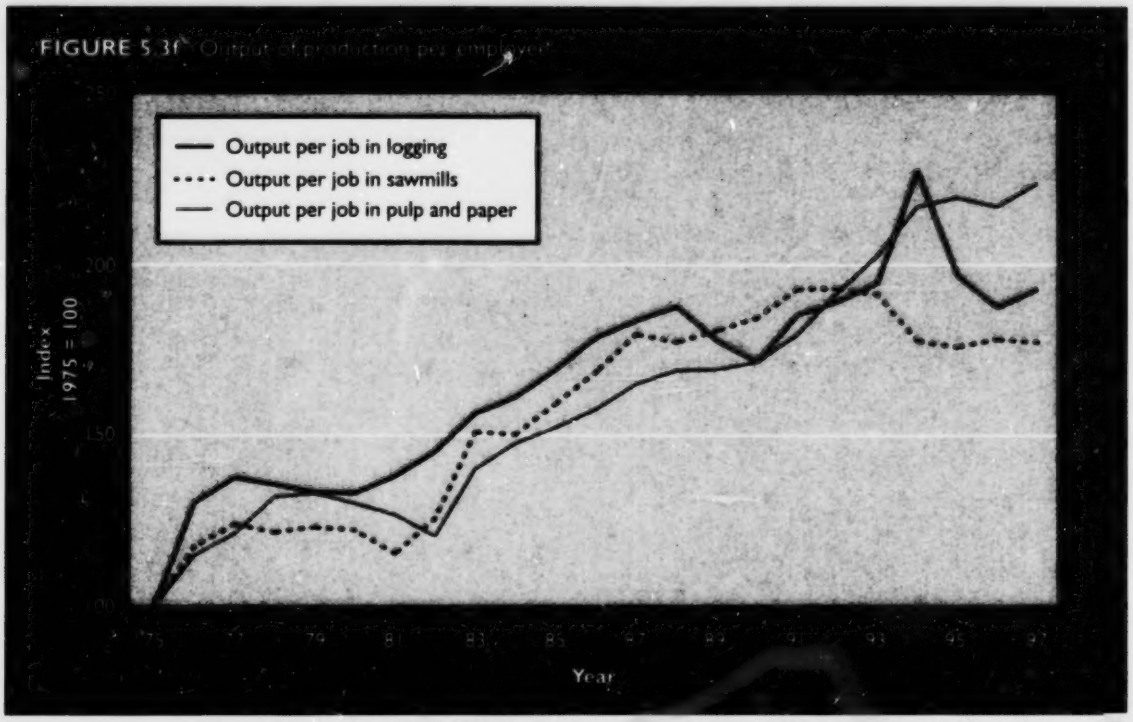
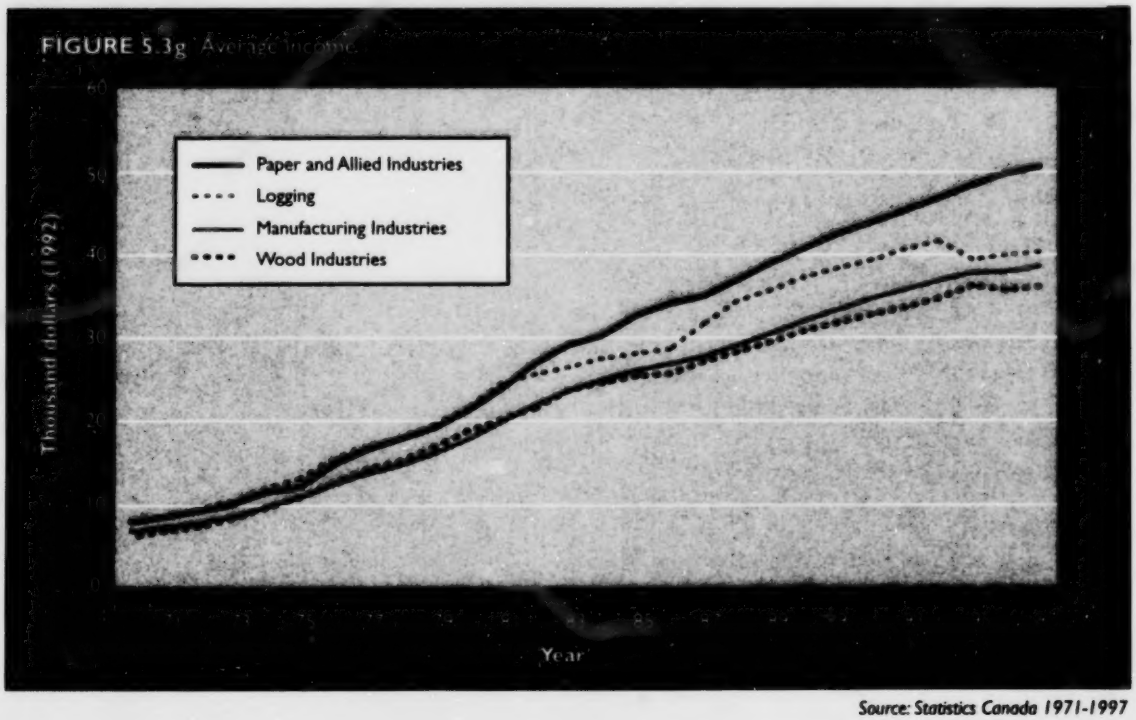


FIGURE 5.3e Direct employment in Canada's forest sector

Sources: Statistics Canada 1975-1998, Natural Resources Canada—Canadian Forest Service 1998



Sources: Statistics Canada 1975-1998, Canadian Pulp and Paper Association 1998, Canadian Council of Forest Ministers 1998



Source: Statistics Canada 1971-1997

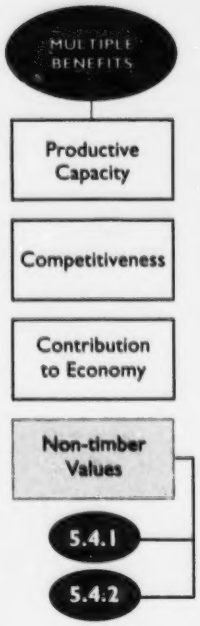
ELEMENT 5.4
NON-TIMBER VALUES

ELEMENT OVERVIEW

Canadians have indicated that in addition to commercial wood products, they look to forests for an array of non-timber benefits, including recreation, tourism and preservation values. The latter may include the option to visit forests in the future (option value), the knowledge that forests are being protected (existence value) and the assurance that future generations will also have access to forests (bequest value).

Non-timber values have become important to Canadians and are expected to play an increasing role in forest use. It is difficult to place a numerical value on non-timber and recreational values because access to the natural resource is generally not allocated through markets and is typically available to all free of charge or for a fee that does not reflect the cost of providing it. Although it is gradually improving, the lack of market information on the social benefits of non-timber values presents a challenge for the policy makers, planners and foresters who must make difficult choices regarding the balancing of benefits.

Canadians' participation in forest-related recreation is on the rise, and it is clear that non-timber uses of the forest must be considered jointly with all other uses to ensure that forests continue to be managed sustainably and to meet the demands placed on them. Public ownership of the majority of Canada's forest land allows accessibility to forest recreation opportunities. Canada's forests are a popular recreation destination for both residents and non-residents (Indicator 5.4.1). Each region of the country has a unique forest landscape that offers different recreational possibilities. Forests and national/provincial/territorial/municipal park systems provide individuals with the opportunity to engage in outdoor activities such as backpacking, climbing, camping, hunting, fishing, swimming, horseback riding, skiing, snowmobiling, picnicking, birdwatching, sightseeing, and observing wildlife. The availability and use of these recreational opportunities can be measured using information on the frequency of visits to recreational areas or the number of people participating in various activities such as recreational fishing, hunting or wildlife viewing.



The *National Survey on the Importance of Nature to Canadians* (Federal-Provincial-Territorial Task Force on the Importance of Nature to Canadians 1999), which has com-piled information for selected years between 1981 and 1996, provides one of the most comprehensive databases on Canadians' activity patterns and expenditures for outdoor recreation. The Survey indicates that Canadians are spending more time participating in forest-related activities and may be placing increasingly higher value on forest visits and activities. The importance Canadians place on the non-timber uses of forests can be observed in part through their expenditures on forest recreation (5.4.2). The survey collected information on nature-related expenditures, many of which involve forests. In 1996, Canadians spent approximately $11 billion on nature-related activities. The billions of dollars spent by Canadians on these activities contribute significantly to national and provincial economies in the form of income and jobs.

INDICATOR REPORTS

5.4.1 AVAILABILITY AND USE OF RECREATIONAL OPPORTUNITIES

The results of the *National Survey on the Importance of Nature to Canadians* (Federal-Provincial-Territorial Task Force on the Importance of Nature to Canadians. 1999) suggest that a large number of Canadians participate in forest-related nature experiences. In 1996, 84.6% of the population aged 15 years and over participated in one or more nature-based activities.

Table 5.4a describes the number of user-days spent participating in nature-based activities in 1996. A user-day is defined as all or any part of a calendar day (24 hours or less) spent participating in a given nature-based activity. Canadians spent more than 165 million days participating in activities ranging from hiking, camping, canoeing, skiing, birdwatching, fishing, hunting, berry picking, and other activities, in natural

TABLE 5.4a Number of days (million user-days) spent participating in nature-based activities in 1996

	All outdoor activities*	Wildlife viewing**	Recreational fishing	Hunting
Forested Ecoprovinces	14.3 (86.5%)	1.1 (77.3%)	2.7 (87.3%)	1.2 (87.8%)
Non-forested Ecoprovinces	2.2 (13.5%)	0.3 (22.7%)	0.4 (12.7%)	0.2 (12.2%)
Total	16.6 (100%)	1.4 (100%)	3.1 (100%)	1.4 (100%)

**Outdoor activities include: sightseeing in natural areas, gathering nuts, berries and firewood, picnicking, camping, swimming, canoeing, power boating, hiking, backpacking, climbing, horseback riding, cycling, off-road vehicle use, downhill skiing, cross country skiing, snowshoeing, snowmobiling, and relaxing in the outdoors.*

***Wildlife viewing includes: watching, feeding, photographing or studying wildlife.*

Source: Federal-Provincial-Territorial Task Force on the Importance of Nature to Canadians 2000

FIGURE 5.4a Forested ecoprovinces of Canada

Source: Lowe et al. 1996, Marshall and Schut 1999

TABLE 5.4b Expenditures (million dollars) on nature-related activities in Canada in 1996

	Outdoor activities in natural areas	Wildlife viewing	Recreational fishing	Hunting
Accommodation	1 133.9 (16%)	65.7 (5%)	157.5 (8%)	39.0 (5%)
Transportation	1 884.8 (26%)	155.6 (12%)	363.5 (19%)	166.5 (20%)
Food	1 565.9 (22%)	100.0 (8%)	244.7 (13%)	99.4 (12%)
Equipment	2 213.5 (30%)	708.3 (54%)	932.5 (48%)	382.9 (46%)
Other items	448.6 (6%)	272.2 (21%)	236.7 (12%)	136.1 (17%)
Total	7 246.7	1 301.8	1 934.9	823.8
Average yearly expenditure per person (dollars)	704	297	462	692
Average daily expenditure per person (dollars)	44	17	27	41

Source: Federal-Provincial-Territorial Task Force on the Importance of Nature to Canadians 2000

areas. Destination choices are affected by many factors, including aesthetics, ecosystem health and robustness, vegetative characteristics of the area, presence of lakes and rivers, wildlife population status, wildlife diversity and observation potential, access, degree of congestion, availability of facilities, and topography.

A significant proportion of days spent on trips for outdoor nature-based activity occurs within forested areas. Figure 5.4a shows the distribution of forested ecoprovinces in Canada. The 15 terrestrial ecozones of Canada are subdivided into 53 ecoprovinces. Table 5.4a shows that 86.5% of the total days spent on outdoor activities, wildlife viewing, and fishing and hunting in Canada were spent in forested ecoprovinces. The high level of participation in nature-based activity in forested areas is an indicator of the importance and value of forests in providing opportunities for Canadians to enjoy nature-based activities. Moreover, these results emphasize the need to ensure that nature-based activities and forest characteristics required for those activities are considered in forest policy, land-use planning, and management.

Outdoor nature-based activities are often associated with national and provincial parks. Figure 5.4b illustrates the number of visits to Canada's forested national parks. In 1996-1997 there were close to 14 million person-visits to Canada's forested national parks. The majority of these visits took place during the period from June to September. Each time a person enters a national park for the purpose of recreation is considered a person-visit. Local residents, through-traffic and employees are not included. Between 1990 and 1996, the number of visits to Canada's parks increased almost 14%, and it is expected that the trend will continue. This increase suggests that since more individuals are spending more of their leisure time participating in forest-related activities, they may also be placing higher value on these activities.

However, the results of the national survey indicate that 52.5% of days are also spent on activities in forest areas outside parks. In the case of recreational fishing, 76.4% of user-days occurred outside national and provincial parks.

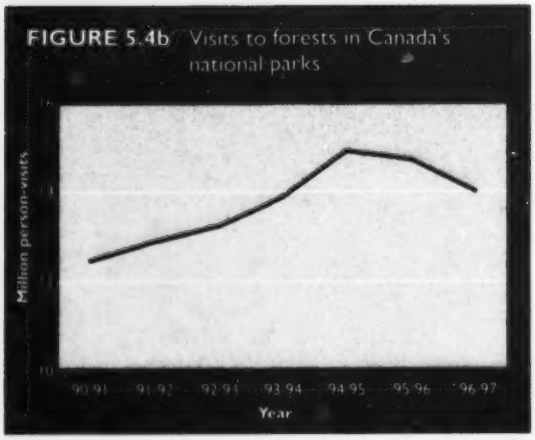


FIGURE 5.4b Visits to forests in Canada's national parks

Source: Canadian Heritage—Parks Canada 1999

5.4.2 TOTAL EXPENDITURES BY INDIVIDUALS ON ACTIVITIES RELATED TO NON-TIMBER USE

Table 5.4b shows the breakdown of expenditures on nature-based activities in Canada in 1996. Total expenditures by Canadians on trip-oriented, nature-based activities were over $11 billion. Nature-based expenditures involving forests include those for transportation, accommodation, food, entry fees and equipment and supplies such as camping, hunting and fishing gear, outdoor clothing and cameras. It is important to note, however, that expenditures on activities are generally lower than the actual value of the experience to individuals. A study by Reid (1998), for example, showed that the economic value of activities such as watching, feeding, studying, or photographing wildlife in British Columbia (on an average per day basis) is about twice as high as average daily expenditures. The correct interpretation of expenditure data is therefore as a relative measure of the economic or social value of the activity. Information on expenditures can also be used to assess the local economic impact of various nature-based activities.

The importance of ecotourism as a source of economic development is growing as more and more individuals travel to natural areas for outdoor experiences. Expenditures by individuals who travel to remote areas create jobs and contribute to economic development. The majority of expenditures on nature-based activities are for general outdoor activities such as camping, hiking, and canoeing. The high percentage of expenditures in accommodation and transportation suggests that individuals who participate in general outdoor activities are more likely to take overnight trips to the destination where the activity occurs.

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CRITERION 6

ACCEPTING SOCIETY'S RESPONSIBILITY FOR SUSTAINABLE DEVELOPMENT

INTRODUCTION

6.1 Aboriginal and Treaty Rights

- 6.1.1 Extent to which forest planning and management processes consider and meet legal obligations with respect to duly established Aboriginal and treaty rights

6.2 Participation by Aboriginal Communities in Sustainable Forest Management

- 6.2.1 Extent of Aboriginal participation in forest-based economic opportunities
- 6.2.2 Extent to which forest management planning takes into account the protection of unique or significant Aboriginal social, cultural or spiritual sites
- 6.2.3 Number of Aboriginal communities with a significant forestry component in the economic base and the diversity of forest use at the community level
- 6.2.4 Area of forest land available for subsistence purposes
- 6.2.5 Area of Indian reserve forest lands under integrated management plans

6.3 Sustainability of Forest Communities

- 6.3.1 Number of communities with a significant forestry component in the economic base
- 6.3.2 Index of the diversity of the local industrial base
- 6.3.3 Diversity of forest use at the community level

6.4 Fair and Effective Decision-Making

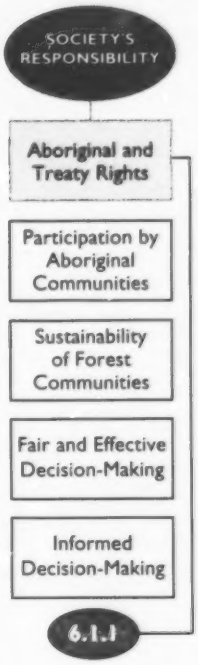
- 6.4.1 Degree of public participation in the design of decision-making processes
- 6.4.2 Degree of public participation in decision-making processes
- 6.4.3 Degree of public participation in implementation of decisions and monitoring of progress toward sustainable forest management

6.5 Informed Decision-Making

- 6.5.1 Percentage of area covered by multi-attribute resource inventories
- 6.5.5 Expenditure on international forestry

INTRODUCTION

ACCEPTING SOCIETY'S RESPONSIBILITY FOR SUSTAINABLE DEVELOPMENT



Sustainable development extends beyond trees to encompass the people in forest communities. Criterion 6 is about society's values and the effectiveness with which all members of society ensure that forest resources are managed in a manner that is in the best interests of present and future generations. The indicators in Criterion 6 measure social dimensions of sustainable development.

The Canadian Constitution recognizes and affirms the existence of Aboriginal and treaty rights. Element 6.1 *(Aboriginal and Treaty Rights)* reviews the current legislation, policies and practices to determine the extent to which Aboriginal and treaty rights are considered in forestry planning and management.

The right of Aboriginal people to strengthen their connections to the land and to the resource-based economy has been increasingly recognized in recent years. The degree to which this recognition is being integrated into forest management plans and practices is the focus of Element 6.2 *(Participation by Aboriginal Communities in Sustainable Forest Management)*. The share of timber and non-timber benefits from the forest accruing to Aboriginal people, and the consideration in forest management plans for the protection of their cultural and spiritual heritage are examined.

A prosperous and developed community based on sustainable forest management contributes significantly to the well-being of all Canadians. Element 6.3 *(Sustainability of Forest Communities)* examines the number of forest-dependent communities in Canada, their economic diversity, and the diversity of their forest use.

Canadians have been calling on foresters and policy makers to ensure that forest management reflects changing social values. Element 6.4 *(Fair and Effective Decision Making)* reviews the extent to which the public is involved in charting out a path toward sustainable forest management, the mechanisms used, and their effectiveness.

For the public to be more engaged in decision-making processes regarding forest use and management, an understanding of forest ecosystems and the relationships between the environment and the economy is necessary. Element 6.5 *(Informed Decision Making)* examines our collective understanding of forests and reports on the type of data currently being maintained in forest inventory databases. It also discusses Canadian contributions to assist other countries in advancing their understanding and implementation of sustainable forest management.

ELEMENT 6.1 ABORIGINAL AND TREATY RIGHTS

ELEMENT OVERVIEW

"Aboriginal people", as defined by the *Constitution Act* (1982), includes the Indian, Metis and Inuit peoples of Canada. There is growing awareness of the need for sustainable forest management to recognize Aboriginal people's rights and to protect their traditional way of life. Sustainable forest management considers Aboriginal use of forest land, whether it be subsistence or commercial fishing, hunting, trapping or gathering.

Element 6.1 attempts to measure the extent to which forest planning and management processes throughout Canada consider and meet legal obligations with respect to Aboriginal and treaty rights. "Aboriginal rights" refer to general rights, typically defined by the

Constitution or federal legislation ascribed to Indian peoples or First Nations. The term "First Nation" came into common usage in the 1970s to replace the word "Indian". Although the term First Nation is widely used, no legal definition exists. Among its uses, the term "First Nations people" refers to the Indian people in Canada, both Status and Non-Status. Many Indian people have also adopted the term "First Nation" to replace the word "band" in the name of their community. In some provinces/territories, Aboriginal rights include the right to subsistence or commercial fishing, hunting, trapping, gathering or timber harvesting and may include the right of consultation. Aboriginal rights vary from group to group depending on the customs, practices and traditions that are part of their distinctive cultures.

Clear property rights and use, in conjunction with the assurance that these rights will be recognized through due process, are important for sustainable forestry. If ownership of the forest or access to its resources is assured to those who depend on it for subsistence or other needs, there is a greater probability that these users will take responsibility for sustainable forest management. Land claims and treaty entitlements are on-going processes. Measuring the extent to which forest planning and management processes consider and meet obligations with respect to Aboriginal and treaty rights is difficult because of changing interpretations of those rights and the evolving forms of co-management between Aboriginal people, provincial governments and the forest industry. The extent to which each province and territory is taking action to acknowledge and incorporate Aboriginal and treaty rights into forestry planning and management is described (Indicator 6.1.1).

INDICATOR REPORT

6.1.1 EXTENT TO WHICH FOREST PLANNING AND MANAGEMENT PROCESSES CONSIDER AND MEET LEGAL OBLIGATIONS WITH RESPECT TO DULY ESTABLISHED ABORIGINAL AND TREATY RIGHTS

This indicator is reported through the results of a provincial/territorial survey (Table 6.1a).

Some provinces have amended or are in the process of amending their forest legislation, regulations, practices and policies to address Aboriginal rights. New Brunswick, for example, is currently reviewing possible amendments to its *Crown Lands and Forests Act* (1982) to affirm the recognition of Aboriginal and treaty rights in the management of public lands.

The British Columbia Ministry of Forest's policy on *Aboriginal Rights and Title* (1999) provides guidance to operational staff in addressing potential Aboriginal rights and title issues arising from resource development activities of the government and licensees. The policy and the accompanying detailed *Consultation Guidelines* apply to operational forest planning and approval processes for provincial public land (94% of the province). The policy also encourages Aboriginal involvement in aspects of strategic or long-term planning processes in order to increase the effectiveness of all Ministry planning processes. The policy updated an earlier, similar policy and is consistent with other provincial policies regarding Aboriginal issues. The Ministry of Forests strives to build and maintain working relationships with First Nations based on trust and respect.

In Ontario, the *Crown Forest Sustainability Act* (1994) provides the Ministry of Natural Resources with the legislative authority for the sustainable management of Ontario's forest resources. The legally prescribed forest management planning process provides for separate and customized participation of Aboriginal communities. The Ministry is presently implementing and complying with Term and Condition 77 of the *Class Environmental Assessment for Timber Management on Crown Lands in Ontario* (1994), which addresses the need for more equal participation by Aboriginal people in forest management and in the sharing of benefits. Term and Condition 77 prescribes the creation of a mechanism through which Aboriginal communities can pursue economic development; however, it does not recognize any treaty or Aboriginal right to commercial use of forest resources.

The development of a comprehensive database on provincial and territorial efforts to incorporate Aboriginal and treaty rights into forest planning and management would facilitate future reporting on this indicator.

TABLE 6.1a Provincial and territorial legislation, regulations and policies acknowledging Aboriginal and treaty rights in forest planning and management

Province/Territory	Policy/Process
Alberta	Presently undertaking a complete review of existing consultation processes to ensure that the government is meeting its legal responsibilities to Aboriginal and treaty rights.
British Columbia	Operational forest planning and approval processes must address Aboriginal and treaty rights, as required by the Ministry of Forests *Aboriginal Rights and Title* policy and detailed *Consultation Guidelines*. The policy also encourages Aboriginal involvement in strategic or long-term planning processes.
Manitoba	Information not available.
New Brunswick	Affirms that its processes will respect Aboriginal and treaty rights as established in law. Amendments to the *Crown Lands and Forests Act* to affirm the recognition of Aboriginal and treaty rights in the management of public lands are presently under consideration.
Newfoundland and Labrador	Principle of Aboriginal participation will be met through negotiation of comprehensive land claims with Aboriginal groups whose claims have been been accepted for negotiation by the government.
Northwest Territories	*Forest Management Act* provides control, management and administration with respect to research, harvest, and management of forests.
Nova Scotia	Information not available.
Nunavut	Information not available.
Ontario	The legally prescribed forest management planning process provides for separate and customized participation of Aboriginal communities. Term and Condition 77 of the *Class Environmental Assessment for Timber Management on Crown Lands in Ontario* addresses the need for more equal participation in the benefits of forest management by Aboriginal people. Although the government is legally bound to comply with the forest management planning process and the Terms and Conditions of the *Class Environmental Assessment*, successful implementation of these policies requires the involvement of the Aboriginal community.
Prince Edward Island	Information not available.
Quebec	Has for some years encouraged the participation of local Aboriginal communities in the management of public forests. The forest industry also has Aboriginal input into the first stages of the planning process. The *Forest Act* is being amended to include customized participation of Aboriginal communities.
Saskatchewan	*The Forest Resources Management Act and Regulations* proclaimed April 1999 affirm recognition of Aboriginal and treaty rights. The act requires consultation with Aboriginal people by industry when developing forest management and operating plans. Will initiate in 2000 discussions with First Nations about a consultation process for reviewing forest operating plans.
Yukon Territory	Legal obligation for consultation on management planning expressed in the *Umbrella Final Agreement* and individual final land claims (Chapter 17).

Source: Natural Resources Canada—Canadian Forest Service—Industry, Economics and Programs Branch 1999

ELEMENT 6.2
PARTICIPATION BY ABORIGINAL COMMUNITIES IN SUSTAINABLE FOREST MANAGEMENT

ELEMENT OVERVIEW

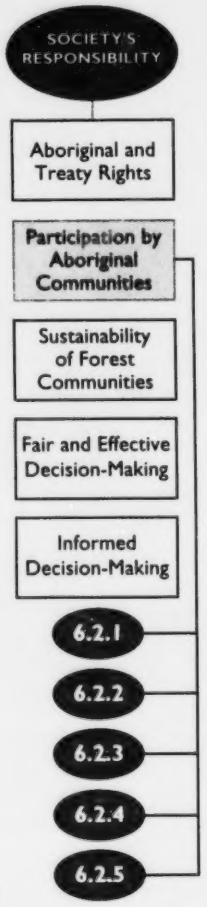
Given Aboriginal people's ties to the forest, and the traditional knowledge they have gained through their special relationship with the land, they bring a unique perspective to sustainable forest management. There is much wisdom in the Aboriginal land ethic which holds that land and forests should be viewed as a whole, and that resources must be protected out of respect for past, present and future generations.

More than 80% of Aboriginal communities lie within or near productive forest zones of Canada. The participation of these communities in making decisions on sustainable forest management is therefore important (Indicator 6.2.1). Based on information provided by provinces and territories as well as recent studies, it can be concluded that the number of Aboriginal people working in forestry and forestry-related businesses has grown considerably since the mid-1990s due to greater employment opportunities offered to them by governments and industry.

The federal government has responsibility for land areas referred to as "Indian reserves". There are 2 592 reserves located across Canada. The total area of these reserves is 3.2 million hectares, 1.4 million hectares of which are forested. The forest land on Indian reserves is equal to approximately 0.3% of the forest land in Canada. Forest management plans from 286 First Nations communities were reviewed to determine the extent to which the recognition, location and protection of important social, cultural and spiritual sites (Indicator 6.2.2) were considered in current plans.

The participation of Aboriginal communities in all stages of sustainable forest management, from planning to economic opportunities, includes diversified use of forest resources (Indicator 6.2.3) to ensure community sustainability. Less than 1% of communities designated as Aboriginal, pursuant to the definition developed by Aboriginal Business Canada and Statistics Canada, are dependent on the forest sector for a significant proportion of their wages.

Sustainable forest management includes balancing industrial, recreational, and various non-timber and subsistence uses (Indicator 6.2.4) without compromising forest integrity and productivity. While subsistence activities are not exclusive to Aboriginal people in Canada, more than 450 of the 623 First Nations communities in Canada are located in forested ecosystems, and many First Nations from across Canada continue to practice subsistence harvesting and gathering in the forests. It is not possible for this report to provide national information on the area of land available for subsistence purposes. Analysis of two case studies describe how subsistence uses in two northern communities yielded higher economic value than was attributed to commercial forest activities over the past 30 years.



Forest plans provide overall direction and guidelines for meeting specific targets for all resource values. Aboriginal communities value forests for their economic, spiritual, cultural and traditional uses. Management plans that integrate these traditional uses with timber and non-timber values (Indicator 6.2.5) are important tools for ensuring that they are recognized and protected. The preparation of a plan is the initial step. The plan must then be implemented and updated on a regular basis.

The Canadian Forest Service keeps some information on forest management plans for Indian reserves. There is no information for the Metis or Inuit communities. The forest management plans reviewed for reserve lands of 286 First Nations communities cover approximately 0.75 million hectares of forest.

INDICATOR REPORTS

6.2.1 EXTENT OF ABORIGINAL PARTICIPATION IN FOREST-BASED ECONOMIC OPPORTUNITIES

Comprehensive national data are not available to determine the number of Aboriginal people employed in Canada's forest sector. The only data collection that does take place is on an ad hoc basis. The methodology for collecting the information varies between agencies, as do definitions, and no standard conversion factors are used. Further, employment statistics are not recorded by ethnic origin. Provinces and territories provided estimates on the number of Aboriginal people working in forestry and the forest-based industries, as well as information on studies undertaken since 1994 describing Aboriginal employment in other areas.

The Aboriginal Affairs Section of the British Columbia Ministry of Forests carried out an *Aboriginal Participation Survey* in 1993, which indicated that the number of Aboriginal people employed in the forest industry was approximately 4.3% of the work force. Most of these jobs were in the labour and machine operation areas. Approximately 6% of all industry contracts in the province went to Aboriginal firms. No actual employment numbers were provided.

The Ontario Ministry of Natural Resources is actively involved with more than 70 First Nations communities to facilitate access to economic development through forest management. A number of forest sector companies are taking a lead role in providing employment opportunities and access to the forest resource.

In New Brunswick, an estimated 470 jobs, or 4 700 work weeks of forestry employment, were generated for Aboriginal people through the 1998 interim harvesting agreements between the province and the 15 First Nations communities.

In the Northwest Territories, it is estimated that 3 000 Aboriginal people are engaged in forestry-related activities, including firefighting, and 60 in forest-based processing operations.

6.2.2 EXTENT TO WHICH FOREST MANAGEMENT PLANNING TAKES INTO ACCOUNT THE PROTECTION OF UNIQUE OR SIGNIFICANT ABORIGINAL SOCIAL, CULTURAL OR SPIRITUAL SITES

It is not possible to comprehensively report on the recognition, location and protection of important social, cultural and spiritual sites in current forest management plans for Indian reserves. Little information is available from the provinces and territories regarding new legislation, policies or programs affecting important Aboriginal sites. No data are available for the Metis population. The report for Indicator 6.2.2 is based on available information regarding forest management plans for Indian reserves.

Many provinces and territories have legislation or programs that do address this issue. In Ontario, the legally prescribed forest management planning process provides for separate and customized participation of Aboriginal communities. In addition, Ontario has forest management guidelines for the protection of cultural values that pertain to all public forests. Quebec and British Columbia have heritage conservation legislation in place to manage Aboriginal archaeological sites. Its traditional use study program provides funds to First Nations to collect, store, maintain and map traditional use site information. In the Northwest Territories and the Yukon Territory, forest management plans are being developed in conjunction with community protection and municipal plans. These plans are in the preliminary stages. All social, cultural and spiritual sites will be considered as most communities are small and have many residents of Aboriginal descent.

Table 6.2a shows the number of Indian bands with forest management plans that address or include the protection of unique or significant social, cultural or spiritual values. Less than half of the plans reviewed recognize the social values of the lands under management, while fewer still recognize important cultural and spiritual sites. Information with respect to how well the social, cultural and spiritual values of the forests are being protected or how well they are recognized and acknowledged in forest planning and

TABLE 6.2a Forest management plans for Indian reserves that consider unique or significant social, cultural or spiritual values

Number of First Nation communities with forest management plans	Number and percent of plans incorporating Aboriginal values					
	Social	%	Cultural	%	Spiritual	%
286	138	48	104	36	40	14

Source: Natural Resources Canada—Canadian Forest Service—Industry, Economics and Programs Branch 1999

management should become available as existing plans are updated or new ones are prepared for reserve lands.

6.2.3 NUMBER OF ABORIGINAL COMMUNITIES WITH A SIGNIFICANT FORESTRY COMPONENT IN THE ECONOMIC BASE AND THE DIVERSITY OF FOREST USE AT THE COMMUNITY LEVEL

Aboriginal Business Canada and Statistics Canada developed a list of Aboriginal communities from the 1996 Canada Census (Statistics Canada 1998). Their list included all census subdivisions (CSDs) which had a self-identified population of 20% or more of any one of the following groups: North American Indian, Metis or Inuit; or that were designated by Statistics Canada as Indian Reserve, Indian Settlement, Indian Government District, Terres reservées or Village Cri. From this list, the economic base method was used to determine how many of these CSDs have over 50% of their economic base in the forest sector.

"Census subdivision" is the general term applied to municipalities (as determined by provincial legislation) or their equivalent (for example, Indian reserves, Indian settlements and unorganized territories) (Statistics Canada 1998). This is the same method used in Indicator 6.3.1.

Of 1 052 Aboriginal CSDs, data are available for 750. Seven of these were found to be forest sector-dependent. Five of the forest-dependent communities are located in British Columbia. All of them have populations of less than 1 000. The other two are Metis communities in Alberta and Saskatchewan, with populations between 2 000 and 5 000. Current research does not measure the number of communities dependent on forest subsistence, however. If a full range of forest values were included (e.g., subsistence, amenity, bequest and existence values), the number of forest-dependent communities would substantially increase.

A case study in Waterhen, Saskatchewan, a community of 556 residents, showed that dependence on the forest is greater than typically captured by forest industry dependence measures (Korber 1997). Using traditional harvest survey data for 1992, an in-kind income was estimated based on replacement values. Subsistence activities accounted for approximately one quarter of the total community economy. The analysis from this study also showed that competition between forest uses may arise when subsistence production and industrial forestry share the same land base. These issues are currently being addressed through alternative forest management regimes.

6.2.4 AREA OF FOREST LAND AVAILABLE FOR SUBSISTENCE PURPOSES

There is insufficient information available to report on the area of forest available for subsistence purposes. Burkosky and Beckley (1997) have discussed some of the issues surrounding the rights of Aboriginal people to practise subsistence activities. While subsistence is generally interpreted to mean hunting, fishing, trapping and gathering, many of the court rulings on the subject refer only to fishing and hunting and either do not consider or do not define what may be gathered.

A second complicating factor is that a given tract of land is rarely either entirely accessible or entirely inaccessible for Aboriginal subsistence use. This makes it difficult to develop a national picture of the amount of land available. In addition, in any province or territory there are occasional additions to the land available for subsistence and new exclusions. Such exclusions may occur for purposes of protection (wildlife reserves), for natural resource development (hydro projects, oil sands expansions), or for administrative purposes (government installations). The area of land that is even hypothetically available for subsistence use is constantly changing. To date, no agency or institution has systematically tracked this information.

There is also the question of who qualifies for subsistence rights. Access to land for subsistence purposes differs among First Nations members, Metis, and reserve residents and non-residents.

In case studies in Nahanni Butte and Fort Liard, Northwest Territories, harvests of meat, fish, crafts, pelts, fuel wood and berries were calculated and the potential value of medicine, tourism, spiritual values, building materials and domestic use of crafts estimated. The analysis showed that subsistence and non-industrial forest uses may have more economic value than has been attributed to commercial forest activities over the past 30 years (Beckley and Hirsch 1997).

The Crees of Quebec have estimated that one third of their economy is based upon hunting and fishing and that every Cree is either a direct participant or indirectly benefits from a subsistence economy (Canada, House of Commons 1990). Since 1975 the Crees have tracts of land reserved, under the *James Bay Northern Quebec Agreement*, exclusively for subsistence and commercial purposes. The Narkapis have similar arrangements under the *Northeastern Quebec Agreement.*

6.2.5 AREA OF INDIAN RESERVE FOREST LANDS UNDER INTEGRATED MANAGEMENT PLANS

Table 6.2b shows the number of Indian reserves with forest management plans and the forest area that is under management. It is estimated that 286 First Nations communities have forest management plans, covering over 50% of the total forest land on reserves.

Most reserve management plans are based on an approach to forest management planning that integrates timber and non-timber values. Those that are not based on this concept are found primarily in Ontario and Nova Scotia. As part of integrated management, the British Columbia Ministry of Forests and the Manitoba Department of Conservation have an agreement with the federal Department of Indian Affairs and Northern Development to go onto Indian reserves to fight wildfires. There may be similar agreements in other provinces/territories.

TABLE 6.2b Number of Indian reserves with integrated forest management plans, 1999

Province/Territory	Number of reserves*	Number of communities	Number of forest management plans	Number of integrated forest management plans	% integrated plans	Total forest area under forest management plans (ha)
British Columbia	1 654	197	126	126	100	130 594
Alberta	108	43	23	20	87	124 504
Saskatchewan	185	70	N/A**	N/A	N/A	N/A
Manitoba	121	61	24	24	100	34 593
Ontario	193	126	64	24	38	208 116
Quebec	37	39	20	14	70	230 195
New Brunswick	17	15	9	5	56	12 816
Nova Scotia	24	14	18	5	28	5 128
Prince Edward Island	1	2	1	1	100	278
Newfoundland and Labrador	1	1	1	1	100	294
Northwest Territories* **	2	26	0	0	0	0
Yukon Territory	23	16	0	0	0	0
Total	**2 394**	**610**	**286**	**220**	**77**	**746 518**

* *Department of Indian Affairs and Northern Development—Indian Land Registry System 1999.*

** *N/A: Information not available.*

*** *15 of the 26 First Nations are developing forest management plans in conjunction with community protection and municipal plans. All plans are in the preliminary stages and will involve consultations with communities and various agencies and stakeholders.*

Source: Natural Resources Canada—Canadian Forest Service—Industry, Economics and Programs Branch 1999

ELEMENT 6.3
SUSTAINABILITY OF FOREST COMMUNITIES

ELEMENT OVERVIEW

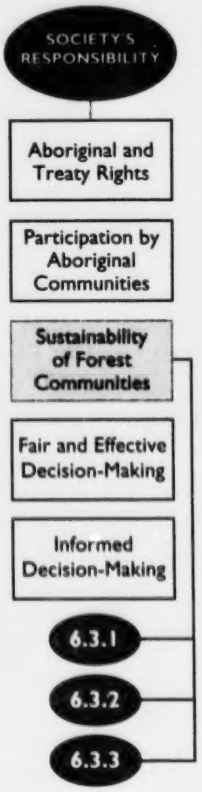
Sustainable forest management is commonly divided into three components: environmental sustainability, economic sustainability and social sustainability. This element focuses on the latter two. Because of the high cost of transporting raw materials from the woodlands to the mill, processing facilities for the forest industry have traditionally been built in rural areas close to the fibre source. This has meant that many communities have a high dependence on the forest sector for their well-being and even their survival. Communities with a high dependence on a single sector of the economy, whose fortunes are often beyond their control, are vulnerable to sudden economic shocks. Changes in the community's economic well-being may also influence its social conditions.

The identification of communities at risk for sudden economic shocks because of changes in timber supply or altered forest conditions is a first step in helping policy makers develop prescriptions to assist those communities in difficult times, and more importantly, to enhance their long term well-being. Indicator 6.3.1 describes the national distribution of 298 communities in Canada that are dependent on the forest sector for at least 50% of their economic base.

Because economic diversification can contribute to regional economic stability, it is an important indicator of the sustainability of forest communities (Indicator 6.3.2). An index of diversity of the local industrial base can be used to give additional information about the effects of market forces on forest-dependent communities.

Forests have a variety of purposes at the community level (Indicator 6.3.3). In addition to the use of wood as raw material for processing, craft products and other non-timber products can be harvested by local citizens, as can food for subsistence purposes. The forests can be used for recreation by some people, and as a source of spiritual strength by others. Three case studies illustrate how some forest communities have diversified.

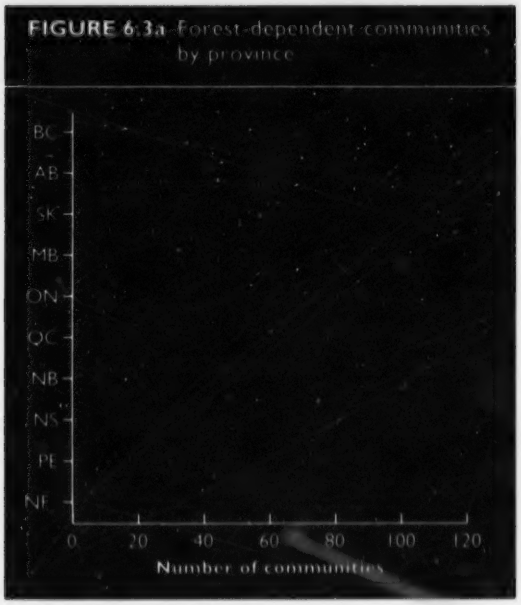
INDICATOR REPORTS



6.3.1 NUMBER OF COMMUNITIES WITH A SIGNIFICANT FORESTRY COMPONENT IN THE ECONOMIC BASE

Figure 6.3a describes the number of forest-dependent communities in Canada by province. Census information (Statistics Canada 1998) was used to estimate the number of census subdivisions (CSDs) in Canada with at least 50% of their economic base in the forest industry. The economic base can be described as the income received by employees of industries that bring money into the economy from outside. For example, a sawmill sends most of its product outside the community, while the money for that product enters the local economy through the mill and its workers. People receiving all of their income from government transfers (pension plans, unemployment assistance, welfare) are included in the economic base as those funds are generated outside the community. Using this methodology, 298 of the 5 248 CSDs in Canada for which data are available were found to have a forest industry component of 50% or more in their economic base.

With this level of dependence on the forest sector, the importance of practising sustainable forest management is evident. While sustainable forest management cannot protect these communities from downturns caused by market forces, it can ensure that a steady flow of timber and other products and services from the forest are available to benefit local citizens.



* NF: Newfoundland and Labrador.

Source: Natural Resources Canada—Canadian Forest Service 2000.

While the focus of much work on forest dependency has been in identifying communities that rely on the forest industry as their primary source of wealth, other rural and remote communities depend on the forests to attract visitors or for subsistence purposes (Beckley 1998, Korber et al. 1998). Although these uses are more difficult to quantify than industrial dependence, they are a crucial aspect of sustainable forest management. Work is underway to provide details on recreational- and subsistence-dependent economies. The inclusion of these types of forest dependence would increase the number of communities in Canada reported as having a significant forestry component in their economic base.

6.3.2 INDEX OF THE DIVERSITY OF THE LOCAL INDUSTRIAL BASE

Indicator 6.3.1 and Indicator 6.3.2 are linked. Rather than measuring the percentage of the economic base associated with forestry, this indicator provides an index number from one of several methods available in the regional science literature. Tracked over time, this measure can identify trends that may not be evident from simply determining the number of forest-dependent communities. For example, if the number of forest-dependent communities is constant or increasing while the index of diversity is dropping, it could mean that communities are becoming less diverse and potentially more vulnerable to market shocks. Likewise, a decline in the number of forest-dependent communities accompanied by an increase in the index of diversity could signal that although forests are being sustainably managed, communities are diversifying their economies to protect themselves against market changes.

Work is underway to produce an index of diversity for each forest-dependent census subdivision.

6.3.3 DIVERSITY OF FOREST USE AT THE COMMUNITY LEVEL

Indicator 6.3.3 is reported through three case studies of diverse forest use at the community level.

Case Study 1 Wikwemikong Community, Ontario

Wikwemikong Unceded Indian Reserve encompasses approximately 42 600 hectares on the eastern end of Manitoulin Island (the world's largest freshwater island). The population is approximately 2 500, most of whom reside in the village of Wikwemikong.

By the 1990s, logging had depleted the forests of the Wikwemikong Reserve. Timber cutting was largely uncontrolled and unrecorded. Repeated "high-grading" operations resulted in an immature, low-value forest dominated by poor quality trees. A sawmill operation was started and failed because the community did not clearly understand the forestry market. A dozen individuals employed seasonally generated revenues of $250 000 per year by harvesting low quality pulpwood.

In 1989 the Wikwemikong Development Commission developed a 20-year forestry management plan and a complementary 5-year operating plan to provide a framework for establishing policies and regulations aimed at ending unregulated timber harvesting and encouraging sustainable forestry while providing long-term benefits to the community. In 1992, the Ontario government chose the Wikwemikong Unceded First Nation as one of only four Community Forest Pilot Projects (Ontario Round Table on Environment and Economy 1995, Harvey 1995) because the reserve was committed to community-based and controlled forestry. Three years of project funding supported the community's efforts to design a comprehensive new forest management

plan. This plan uses silviculture to increase the quality and quantity of the forest and the timber available for harvest, takes into account wild plants and animals as well as traditional forest products, and supports multiple forest uses including the harvest of natural medicinals, forest-based recreation, tourism, nature reserves, wildlife refuge areas and no-cut areas. A timber resource policy was subsequently approved by the band in 1993 to monitor and control harvesting practices on the reserve. A community forest trust fund was established, and an updated forest resources inventory was completed in support of implementing sustainable forest management practices. In 1995 Wiky Forest Products was established as a central timber purchasing, processing and marketing outlet for the Wikwemikong community.

A high level of community involvement has been key to the overall success of this program. Between 1992 and 1996, more than 500 000 trees were planted by the Ontario Ministry of Natural Resources on reserve lands, with a goal of planting an additional 1 million over the next 5 years, and of establishing a local tree nursery to support the planting program. The Wikwemikong forest is used for many non-commercial purposes, including the collection of medicinal and ceremonial plants, raw materials for crafts, and berry picking, as well as forest-based recreation, spiritual values, hunting and fishing, and fuel wood harvest. Commercial harvest operations on the reserve currently produce pulpwood, small dimension lumber, fencing, pallet and pre-cut material. There are now approximately 150 people employed in Wikwemikong's forest operations (harvesting, scaling, silviculture and firefighting), generating approximately $2 million in revenues annually. A new community-owned company has constructed many log homes and buildings, both inside and outside the Wikwemikong community. Profits from commercial forest operations go back to the community-owned company to be reinvested on behalf of Wikwemikong in stand restoration and improvement of silviculture and in multiple-use community forest development.

Case Study 2 Fort Providence, Northwest Territories

Fort Providence is located on the northeast bank of the Mackenzie River approximately 75 kilometres from the mouth of Great Slave Lake. Fort Providence is populated by approximately 600 Dene, Metis and non-Aboriginal people. Dene and Metis residents still practise traditional trapping and hunting lifestyles and participate in the wage economy. The traditional use area of the Aboriginal community covers an estimated area of 53 000 square kilometres.

In August 1998, the Fort Providence Resource Management Board completed the first phase of a traditional land use (TLU) study in which land-use typing and mapping were conducted. Tables 6.3a-6.3e provide summaries of residents' forest use based on this first phase of data gathering (Bonnetrouge and Campbell 1999).

Although the TLU study results show activity type and average area used, it should be noted that forest-use overlap occurs (i.e., one area may be used for more than one forest activity).

TABLE 6.3a Species hunted and trapped in Fort Providence

Species trapped commercially	Species hunted for personal use
Beaver	Bison
Ermine	Caribou
Red fox	Grouse
Lynx	Moose
Marten	Porcupine
Mink	Hare
Muskrat	Squirrel
Otter	Waterfowl (goose and duck)
Hare	
Red squirrel	
Wolf	
Wolverine	

Source: Government of the Northwest Territories 1995-1999

TABLE 6.3b Fishing in Fort Providence

Method	Number of people who fish
Ice fishing	26
Setting of nets	50
Fishing by rod	44
Shellfish collecting	5

Source: Government of the Northwest Territories 1995-1999

The Deh Gah Got'ie Betterment Corporation was formed to address economic development in the community. The Betterment Corporation is directed by three Dene and three Metis board members and consists of retail, general contracting, real estate, tourism, natural resources and manufacturing divisions.

Fort Providence is a partner in the International Crown Fire Model Experiment, which also involves NASA, the Canadian Forest Service, provincial governments, international researchers, the Government of the Northwest Territories and other local communities. The project investigates various aspects of forest fires, including crown fire development modelling in black spruce–jack pine stands, carbon and greenhouse gas cycling in wildfires, equipment research and structural protection.

The Fort Providence Resource Management Board submits yearly prescribed burn proposals to the Department of Resources, Wildlife and Economic Development. The main objective of the prescribed burn activities is to enhance wood bison habitat. A secondary objective, where applicable, is to reduce the fire hazard in grasslands as a community protection strategy. Prescribed burning supports the vitality of wood bison populations (currently estimated at 1 900 animals), reduces the risks of range deterioration and density-dependent disease outbreaks, and produces new feeding areas. This project was initiated in 1993 with an average of 10 000 hectares being burned annually in the Mission, Bluefish, Moose and Deep Bay Prairies.

TABLE 6.3c Harvesting and gathering in Fort Providence

Type of harvesting and gathering	Number of areas identified	Average area utilized (ha)
Cranberries	16	216
Waterfowl egg collecting	N/A*	642
Dry wood	60	229
Green wood	21	814
Medicinal plants	11	256

**N/A: Information not available.*

Source: Government of the Northwest Territories 1995-1999

TABLE 6.3d Travel and building sites in Fort Providence

Site	Number
Cabins	16
Camp and tent sites (gathering)	7
Historic trails	28
Travel routes	84

Source: Government of the Northwest Territories 1995-1999

Case Study 3: Geraldton Community Forest, Ontario

Geraldton is a small community in northern Ontario with a population of approximately 3 000. Originally established as a mining town, the local economy has since shifted to a forestry base because of the closure of the local mines. With declining employment in the forest sector and uncertain economic prospects, the town of Geraldton began looking for new and innovative solutions to ensure its long-term economic future. Working with the Conservation Council of Ontario, it undertook a feasibility study for a Geraldton Community Forest, involving local management of the public-owned resources in the forest surrounding the town. The approaches recommended for this initiative favoured intensive forest management and stand improvement practices, along with support for tourism and value-added businesses, within a sustainable forest management context. The community forest approach gained wide support, and in 1992 Geraldton was chosen by the Ontario Ministry of Natural Resources as a Community Forest Pilot Project site (Ontario Round Table on Environment and Economy 1995, Harvey 1995).

The Geraldton Community Forest includes seven geographical townships, with an area of approximately 65 000 hectares, and the Town of Geraldton located roughly in the centre. The forest is located entirely within the Boreal Forest, with black and white spruce, jack pine and balsam fir being the dominant conifer species, and trembling aspen and white birch being the primary hardwood species. The area has a short growing season and harsh continental climate. Soils consist primarily of stony but productive sandy till, with depths from no soil on exposed bedrock to five metres in less broken topography. Seventy-five percent of the area is productive forest, and 12.5% is classified as water and islands.

The Geraldton Community Forest Inc. was established as a non-profit corporation in 1994 with

the goal of creating an "economically sustainable community through community management of all natural resources using sustainable ecosystem approaches and environmentally sound practices." Specific objectives include:

1. Demonstrating and evaluating the viability of intensive forest management in a relatively small, community-centred boreal forest area;
2. Increasing community self-sufficiency through local management of local resources;
3. Demonstrating the value of holistic, integrated forest management practices in producing multiple outputs;
4. Improving silviculture practices and the quality and yield of timber and wood fibre;
5. Identifying and pursuing forest resource-based economic diversification opportunities;
6. Creating local employment and business opportunities;
7. Supporting the development of a biomass-fueled district heating facility;
8. Providing forest ecosystem educational and management training opportunities;
9. Establishing a forestry training centre;
10. Providing community cultural development; and,
11. Establishing Geraldton as a model regional centre for sustainable development.

Despite such far-ranging objectives, the Geraldton Community Forest initiative seems to have achieved most of the goals set out for it almost a decade ago (Geraldton Community Forest Inc. 1999). A District Heating Facility to heat the hospital and schools has been constructed, fueled by wood waste from local sawmills. In 1994 Geraldton Community Forest Inc. assumed management responsibility for MacLeod Provincial Park, which had been closed by the province as a cost-cutting measure. Local snowmobile trails have been developed. The Community Forest organization has successfully undertaken, and continues to carry out, a number of intensive forest resource management projects, with a current emphasis on forest-fire fighting, tree planting, training, pre-commercial thinning, commercial thinning, slash pile burning, and prescribed burn plan preparation. A number of other projects have also been successfully implemented within the community forest to look at intensive silvicultural treatments and to determine the operational costs involved. A seven-hectare research site has been set up in the Geraldton Community Forest to study the long-term nutrient dynamics of full-tree logging practices. A demonstration forest developed as a local tourist attraction includes trails used for cross-country skiing. A local eco-trail has also been designed and constructed for forest interpretive purposes as well as for use as a fitness trail by local residents.

TABLE 6.3e Trapping summaries for Fort Providence

Species	Number of animals trapped per year			
	1995-1996	1996-1997	1997-1998	1998-1999
Wolf	14	42	16	6
Beaver	132	235	164	47
Ermine	13	15	31	20
Red fox	13	27	24	7
Lynx	71	179	162	140
Marten	347	581	526	448
Mink	43	55	40	14
Otter	0	1	0	1
Muskrat	41	44	116	17
Black bear	0	1	0	0
Red squirrel	38	38	195	13
Coyote	0	0	1	0
Total animals trapped	**712**	**1 218**	**1 275**	**713**
Number of trappers	**62**	**79**	**65**	**53**

Source: Government of the Northwest Territories 1995-1999

ELEMENT 6.4
FAIR AND EFFECTIVE DECISION-MAKING

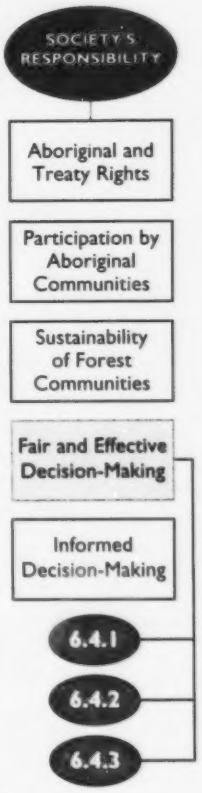
ELEMENT OVERVIEW

In Canada, public participation in forest management is increasingly viewed as a critical element of sustainability. Canadians continue to demand a greater voice in forest management, particularly on public land. Element 6.4 assesses the degree to which the demand for greater public input is being met by public and private institutions, and the mechanisms that are being used for public consultation.

Government agencies across Canada have adopted the consultative approach to developing forest policy and they routinely seek public opinion and work closely with forest industries, Aboriginal groups and environmental organizations to incorporate recreational, social, biodiversity and economic values into forest management planning and decision making.

British Columbia's strategic land use planning and timber supply reviews during the 1990s involved systematic and substantive efforts to engage the public. Nova Scotia recently held a public comment process for two sets of regulations under the *Nova Scotia Forests Act*. New Brunswick witnessed tremendous interest and participation in public involvement opportunities on a proposed protected areas strategy in 1999. In Ontario, public participation in land use and forest management planning is routine and legally prescribed. All forest management plans require extensive public involvement. The recent *Lands for Life* land use planning initiative involved thousands of citizens from all parts of Ontario. Alberta's *Forest Conservation Strategy* and *Special Places 2000* programs canvassed the public on future land management, while the *Forest Legacy* initiative reaffirmed Alberta's commitment to innovative public involvement practices. In 1998, Quebec undertook a major review of its forest management system, including a public consultation that resulted in the submission of more than 500 briefs by stakeholder groups. Subsequent amendments to Quebec's *Forest Act* (Bill 136) are currently under public review. These provincially sponsored efforts continue across the nation.

While assessments may be made of individual processes that provide opportunities for public involvement, it is not possible to provide qualitative measures of public participation at the national level. A survey was conducted to determine the types of public involvement mechanisms employed by large licence holders on public lands, and who is involved in designing them. These companies manage the timber on millions of hectares of publicly owned forest and therefore represent the frontline of forest management. They are in the best position to incorporate public input into forest management plans. The land area under licence to the 63 companies that responded to the survey covers more than 54 million hectares.



Indicator 6.4.1 outlines the role of the public in designing public involvement mechanisms in order to ensure that appropriate mechanisms are used and that the public is involved at the proper stages of the planning process. The assumption is that those participating in consultation processes should have some say in how their opinions are solicited. Survey results indicate that many companies do involve the public in the design of public involvement processes.

The type of public involvement tool and the nature of the information sought is discussed in Indicator 6.4.2. Of the eight consultation mechanisms specified in the survey, five are used by more than 50% of respondents for their annual operating plans. For long-term planning, companies tend to use public involvement tools even more. Companies seek input on a wide range of issues from the location of harvest blocks to overall management goals. They rarely ask for outright expressions of support or opposition to their plans.

Indicator 6.4.3 is reported through a case study describing how the management planning process, developed in a model forest, has incorporated participation by the public in forestry issues.

INDICATOR REPORTS

6.4.1 DEGREE OF PUBLIC PARTICIPATION IN THE DESIGN OF DECISION-MAKING PROCESSES

The Canadian Forest Service conducted a survey of large licence holders to determine who is involved in the selection or design of mechanisms for measuring public involvement. The intent was to identify the level to which the public or stakeholder groups influence these processes relative to other parties such as the companies themselves, provincial governments, consulting firms, local government and academics. In most cases, the companies surveyed hold an area—rather than a volume-based licence—although there are some exceptions, notably in British Columbia. In total, 138 surveys were distributed and 63 were returned, for an overall response rate of 46%.

The degree to which companies involve the public in the design of public involvement processes is sometimes dictated by the processes themselves. For example, solicitation in various media is a required practice of some licence holders. There are usually provincial guidelines on how to solicit stakeholder input through public registries, and therefore the need for public involvement in the selection or design of such a process would be expected to be low. On the other hand, public involvement in the design or selection of community or face-to-face meetings with industry would be expected to be higher.

The column in bold type in Table 6.4a demonstrates the degree to which the public is involved in the design or selection of the various mechanisms under review. The percentages are calculated based on the number of respondents that confirmed use of a given method. Since not all companies use all methods, the number of responses varies for each strategy.

The survey results suggest that there is room for improvement in processes for involving the public in land management and planning activities. Corporate managers often express frustration with participation levels for community meetings or open houses, and yet only one third of companies involve the public in designing or selecting such processes. Research is currently underway in Canada's model forests to determine which public involvement mechanisms for forest management and planning are preferred by Canadians.

TABLE 6.4a Stakeholder involvement in the selection or design of public participation mechanisms

	Percent responses to the question "Who is involved in the selection of public involvement tools?"			
Tool	**Company staff**	**Provincial government staff**	**Stakeholders or members of the public**	**Other (paid professionals, university staff)**
Open houses	93	49	**29**	6
Stakeholder advisory groups	78	65	**67**	20
Meetings with individuals or individual interest groups	9	25	**26**	7
Community meetings	93	39	**34**	12
Solicitations for public comment	75	55	**22**	10
Surveys of user groups	63	21	**11**	37
Focus groups	84	47	**47**	16
Formal public hearings	67	58	**33**	8

Source: Beckley et al. 1999

TABLE 6.4b Public involvement methods used in forest management planning by licence holders on public lands

TOOL	ANNUAL OPERATING PLANS % using method	MID/LONG-TERM PLANS % using method
Meetings with individuals or interest groups	93	88
Stakeholder advisory groups	78	83
Solicitations for public comment	70	78
Open houses	62	75
Community meetings	56	75
Focus groups	20	30
Surveys of user groups	16	23
Formal public hearings	2	12

Source: Beckley et al. 1999

6.4.2 DEGREE OF PUBLIC PARTICIPATION IN DECISION-MAKING PROCESSES

Table 6.4b shows that of the eight mechanisms specified in the survey, five are employed by more than 50% of respondents for annual operating plans (AOPs). By definition, long-term plans are developed less frequently than AOPs, and often involve more effort and resources on the part of companies. The findings for public involvement methods used for mid- to long-range plans were very similar to the results for AOPs, except that every mechanism but one (meetings with individuals or individual interest groups) was cited more frequently for long-term plans. This confirms that these involve more comprehensive public involvement efforts.

In addition to asking licence holders to describe their public involvement tools, the survey asked about the types of information they solicit from the public for

TABLE 6.4c Type and use of information solicited by large licence holders through public involvement processes

Type of information	Annual Operating Plans Yes (% respondents)	Mid/Long-Term Plans Yes (% respondents)
Location of harvest blocks	84	74
Location of non-timber activity areas (ski, snowmobile, all-terrain vehicle trails)	84	86
Location of roads for accessing timber	84	79
Size of harvest blocks	73	70
Areas for protection	69	83
General expressions of public forest values	53	81
Overall management goals or priorities	53	90
Mitigation strategies	51	60
Volume of fibre removed per unit area	47	47
Location of non-timber product areas (berries, medicinals)	33	54
Tabulation of those in favour of or opposed to the plan	16	17

Source: Beckley et al. 1999

both short-term and medium- to long-term plans. The results are presented in Table 6.4c.

The survey did not attempt to evaluate the quality of the information received from the public, nor the degree to which the licence holders modified their plans to address public concerns. The results indicate, however, that in addition to harvesting issues, licence holders solicit the public on a wide range of issues, including protected areas, non-timber products and activities and overall management activities.

6.4.3 DEGREE OF PUBLIC PARTICIPATION IN IMPLEMENTATION OF DECISIONS AND MONITORING OF PROGRESS TOWARD SUSTAINABLE FOREST MANAGEMENT

As evidenced by the increase in public participation in forest management, many of the major management issues facing foresters and scientists are largely influenced by socio-economic factors rather than by administrative and technical aspects (MacLean et al. 1999). Information regarding how well management plans incorporate public input—and actually use information provided by the public— to improve forest management practices is not available at the national level. Indicator 6.4.3 is reported through a case study examining the development and implementation of a sustainable management planning process in the Fundy Model Forest (MacLean et al. 1999).

Canada's Model Forest Program was initiated in 1992 to develop approaches to forest management that integrate economic, social and environmental objectives. There are presently 11 model forests in Canada, representing all of the country's major forest regions and their unique socio-economic conditions (refer to text box on p. 110).

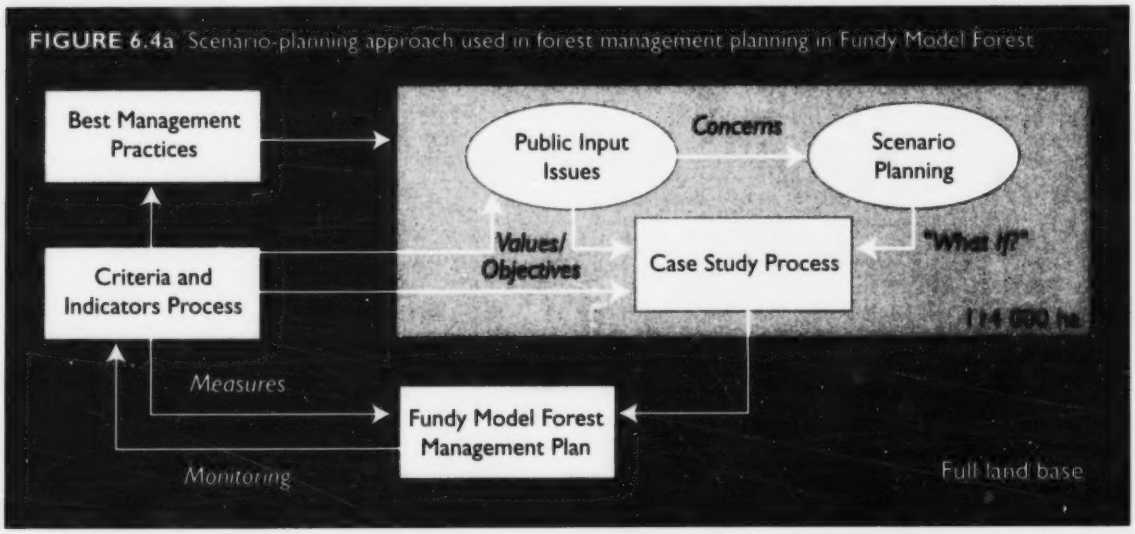
Case Study Sustainable forest management planning in the Fundy Model Forest

Fundy Model Forest (FMF) is a 420 000-hectare working forest located in the Atlantic Maritime ecozone in southeastern New Brunswick. The land ownership is diverse: 63% private woodlots; 15% publicly owned land; 17% industrial freehold land and 5% national park. In addition to these landowners, the FMF partnership includes the participation of over 25 other organizations.

Two of the four original objectives of the FMF relate to the development of a process for producing a management plan to achieve the goal set for each forest value of interest and to specify the specific treatments that are to be implemented.

The FMF partnership has developed a seven-step sustainable forest management planning process (Table 6.4d). The process used a "what if" scenario-planning approach applied to approximately one quarter of the FMF land base (Figure 6.4a). Scenario planning is a structured process for strategic planning that is based

FIGURE 6.4a Scenario-planning approach used in forest management planning in Fundy Model Forest



Source: MacLean et al. 1999

on imagining possible futures. It has been particularly effective when applied to the evaluation of public concerns and contentious issues. A scenario-planning approach often consists of a series of workshops involving land managers, interest groups, stakeholders and the public. This approach serves to identify public and interest group issues and formulate them into a series of scenarios to be evaluated for the land base in question. While scenario planning relies heavily on the expertise, creativity and insight that individuals bring to the planning table, the process can be enhanced when the scenarios are portrayed using a variety of computer models. By consensus, one or a few preferred scenarios are identified through evaluation. The preferred management scenarios are conveyed to land managers for implementation.

This planning approach was used to define 25 scenarios determining effects of alternative means of riparian strip management, road construction, vegetation and insect control, harvesting, maintenance of biodiversity and plantation establishment. Through a series of workshops, the FMF partnership was successful in reaching consensus on a set of "preferred" management scenarios.

While the partnership may influence decisions, it is not a landowner and therefore has no management authority. However, the landowners are generally involved and endorse the planning process and apply it to their own holdings. This has indeed happened in FMF, with the industrial owners and the National Park using the forest management objectives on their land both inside and outside of the area in question. The result is the FMF's planning process being applied to an area three times its size. Ideally this planning process will be adopted by all landowners.

The FMF process has not yet reached on-the-ground implementation, which is the next step. Implementation is more readily achieved on private land because management decisions on publicly owned land must coincide with iterations in the government planning cycle.

Monitoring and evaluation, the final steps in the planning process, determine whether the chosen strategy is being implemented as planned and is having the desired effects. Although the FMF has not yet reached this stage, local level criteria and indicators of sustainable forest management are being developed and implemented for monitoring, evaluation and reporting. The model forest has adopted the definition of sustainable forest management endorsed by the CCFM, using the six criteria as the framework for developing its own suite of indicators. Periodic reporting to the FMF partnership on the status of indicators and planned-versus-actual monitored levels is envisioned.

Functionally linking indicators to forest structural characteristics allows them to be projected into the future as part of the management plan formulation, and to be monitored. A scientific evaluation component to test and improve assumptions and data, and thereby reduce uncertainty in future planning reiterations via adaptive management, is also required. Scenario planning and forecasting of the indicators over time will enable landowners to evaluate and implement a local indicator set. Through the indicators process, the FMF partnership will have direct input into the values and objectives incorporated into landowner management plans.

TABLE 6.4d The Fundy Model Forest planning process

STEP	PURPOSE
Identify forest objectives/values	Basis for setting objectives
Identify treatment tactics	Define actions to consider
Assemble information and management tools	Forecasts of forest change
Analysis of strategies	Explore options, outcomes, tradeoffs
Decision making	Select strategy to implement
Implement on the ground	Talk becomes action
Monitor/Evaluate	Forest effects as expected?

Source: MacLean et al. 1999

The pursuit of sustainable forest management requires the monitoring of effects resulting from management practices and activities. Criteria and indicators such as the national CCFM C&I and international Montréal C&I processes allow for the measurement of progress on a national scale. Local level indicators, which are developed to suit local and regional conditions, provide the framework for monitoring on-the-ground changes and assessing their influence on the many components of sustainable forest management.

A model forest is a place where sustainable forest management practices are developed and tested on local forest areas and then shared across the country. At the heart of each model forest is a group of partners having different perspectives on the social, economic and environmental dynamics within their forest—perspectives that are necessary to make more informed and fair decisions about how to manage the forest. As a common starting point, each model forest utilized the six criteria for sustainable forest management defined by the CCFM C&I framework.

From state of the forest reporting to predicting future forest condition through computer modelling, model forests are putting their local level indicators to work. For more information on these and other model forest activities, please refer to its Web site (http://www.modelforest.net).

CANADIAN MODEL FOREST NETWORK

ELEMENT 6.5
INFORMED DECISION-MAKING

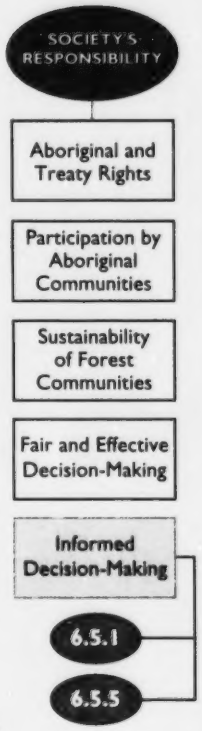
ELEMENT OVERVIEW

Informed decision making refers to the quality of information that goes into forest management. As forest management has undergone transitions from single-species, single-objective management to multiple-species, multiple-objective management to today's complex ecosystem management, the information requirements have increased dramatically. Today, in addition to drawing on traditional disciplines such as forestry and ecology, forest management requires information from such diverse areas as engineering, geomatics, hydrology, genetics, sociology and economics. Fortunately, personal computers, geographic information systems, global positioning systems and other technological developments allow foresters to manage the flow of information. The collection and assessment of such diverse data provide for greater understanding of forest ecosystems and the communication of forest sustainability to the public.

Virtually all public forest land in Canada has been inventoried for two or more attributes (Indicator 4.4.4). The survey discussed in Element 6.4 also questioned large licence holders on public forest land about the types of information they maintained and carried in their inventory databases (Indicator 6.5.1) and the extent of coverage for each of 29 attributes.

Given the importance of forests to the health of the entire planet, responsibility for sustainable management must extend beyond Canada's borders. Expenditures in international forestry (Indicator 6.5.5) is an indicator of informed decision making and society's commitment to sustainability. Canada is working with other nations to resolve global issues such as deforestation and to provide for more informed decision making in the management of all the world's forests. In addition to funding forest programs in developing countries, Canadians are contributing to worldwide efforts to promote a common international framework for sustainable forest management.

INDICATOR REPORTS



6.5.1 PERCENTAGE OF AREA COVERED BY MULTI-ATTRIBUTE RESOURCE INVENTORIES

Virtually all public forest land has two or more attributes inventoried (Indicator 4.4.4). The survey of large licence holders covered an area representing 54 million hectares of Canada's productive forest land. One hundred percent of the area surveyed is covered by multiple attribute resource inventories.

The responses of forestry companies to survey questions concerning their inventory databases are described in Table 6.5a. Not surprisingly, the most popular inventory attributes are those most closely connected with the business of growing and harvesting trees. More than 70% of forest companies surveyed said that they maintain data on species type, age class, access, volumes per hectare, land cover, and a few other variables (silviculture history, topography, location of protected areas, bodies of water/wetlands) for 100% of the land that they manage. Between 5% and 20% of respondents said that they do not maintain data on those specific attributes, but that such data are available elsewhere. Very few indicated that they had no access to data on these attributes.

Some of the least common attributes or inventory items include wildlife travel corridors, habitat of threatened or endangered species, wildlife reproduction areas and feeding or resting sites for wildlife. Although companies may not have much data for these attributes, other agencies or institutions (usually provincial governments) often do. Among the attributes for which companies do not maintain much data and for which few other agencies hold data are vegetation other than trees, oil and gas activity, and soil productivity.

TABLE 6.5a Percentage of area covered by multiple attribute resource inventories maintained by companies surveyed

	Percent of area inventoried within the last 15 years						
Attributes	**100%**	**75–99.9%**	**50–74.9%**	**25–49.9%**	**1–24.9%**	**0%**	**Others***
Land cover	80	5	3	0	2	2	9
Forest type	79	7	3	0	0	2	10
Age classes	74	5	1	0	5	3	11
Water bodies/wetlands	74	8	0	2	0	2	15
Timber volume per hectare	73	6	3	2	8	2	6
Logged areas/harvest history	73	13	0	2	2	2	10
Protected areas	72	3	0	0	7	0	18
Silviculture/renewal history	71	11	0	0	6	2	10
Accessibility/road networks	70	15	2	5	3	0	5
Topography	70	5	2	2	2	3	17
Burned areas/fire history	67	10	5	2	2	0	15
Recreational sites	54	5	9	0	5	3	24
Buffers (riparian, roads, etc.)	54	10	2	5	14	7	8
Vegetation type	52	3	2	2	9	14	14
Ecologically significant areas	47	4	7	2	14	2	25
Watershed/hydrology	47	3	3	3	10	13	20
Oil and gas activity (seismic, pipelines, wells)	45	6	0	0	4	28	17
Fragmentation	43	15	2	0	2	21	25
Mines	43	0	4	0	5	18	30
Soil type	42	4	5	4	14	12	19
Riparian areas important to wildlife	40	3	7	5	8	13	23
Range land	40	0	0	2	4	21	33
Soil productivity	39	2	4	7	9	21	18
Recreational use	36	0	10	0	9	14	32
Vegetation other than trees	29	0	2	2	24	30	14
Feeding, resting or watering sites important to wildlife	22	2	3	7	23	10	33
Important reproduction areas for wildlife	22	0	0	2	30	7	40
Habitat of threatened or endangered species	19	0	7	3	14	14	44
Migratory or travel routes (birds, fish or animals)	5	4	2	0	18	30	41

**Inventory data on this attribute are not maintained but access to such data is available through another agency or institution.*

Source: Beckley et al. 1999

6.5.5 EXPENDITURE ON INTERNATIONAL FORESTRY

As a leader in the development and application of new approaches to sustainable forest management, Canada believes in the mutual benefits to be gained from the sharing of technology and expertise among the world's forest nations. Several government agencies provide funding for forest programs in developing countries, promote sustainable forest management, and work to build international consensus on global forest issues.

Canada (Natural Resources Canada—Canadian Forest Service [NRCan—CFS], the Department of Foreign Affairs and International Trade [DFAIT] and the Canadian International Development Agency [CIDA]), along with 14 partner countries and with support from the Intergovernmental Forum on Forests (IFF) and the Food and Agricultural Organization (FAO), launched the Costa Rica—Canada Initiative to provide a forum for countries and interested parties to express their views on the range of future options for sustainable management of all types of forests and to consider possible elements of legally binding instruments. The findings from the Initiative were consolidated in December 1999 at a meeting hosted by Canada. The final decisions on this convention were released in a report in January 2000 (http://www.nrcan.gc.ca/cfs/crc).

Table 6.5b shows the expenditures on international forestry by three federal government departments/agencies for the fiscal years 1996-1998. The CIDA funds are spent on managing forests, maximizing the environmental potential for trees to enhance agricultural productivity, protecting soil and water, providing basic needs, and helping local people to sustain their forests. The NRCan—CFS expenditures include efforts to meet Canada's international commitments and obligations with respect to forests, implementation of science projects in developing countries, analysis of trends, outlooks and developments in international markets, and maintaining and enhancing Canada's trade in forest products. While the International Development Research Centre (IDRC) does not have a forestry program, it provides the Secretariat for the International Model Forest Network and supports projects on sustainable development, such as land rehabilitation, property rights and human development, that impact on forest issues.

In 1992, an international network of model forests was created to foster cooperation and collaboration in the advancement of management, conservation and the sustainable development of forest resources. The network includes several international model forests established or under development in Canada, Mexico, Russia, the United States, Chile, Argentina, Japan and China. A number of other countries have expressed interest in developing model forests.

TABLE 6.5b Canadian expenditures on international forestry

	Expenditures (million dollars)		
	1996	1997	1998
Natural Resources Canada—Canadian Forest Service [a]	1.7	1.3	1.3
Canadian International Development Agency [b]	60.0	50.0	50.0
International Development Research Centre [a, c]	5.0	5.0	5.0
International Model Forest Network [d]	2.0	1.4	1.4

[a] *International Model Forest Network not included.*

[b] *International Model Forest Network included.*

[c] *IDRC expenditures in natural resource management impacting directly or indirectly on forestry are reported.*

[d] *Includes combined expenditures from CFS, CIDA, IDRC and DFAIT*

Source: NRCan—CFS, CIDA, IDRC 1999

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CONCLUSIONS

Canada's efforts to report on progress toward the sustainable management of forests began in earnest in 1995 with the identification of a framework of criteria and indicators (C&I) by the Canadian Council of Forest Ministers (CCFM). In 1997, *Criteria and indicators of sustainable forest management in Canada: Technical report*, reviewed the data available and described the capacity to report on the individual criteria and indicators. *National Status 2000* represents Canada's first attempt to report on the sustainability of its forests via 62 of the 83 indicators in the CCFMs' national framework of Criteria and Indicators for Sustainable Forest Management as outlined under Action 3.10 in the *National Forest Strategy 1998-2003*.

This report has drawn upon the best available information and the best research and expertise to establish, where possible, a baseline from which progress can be measured in future reports. Measuring the sustainability of forests is a long-term and progressive exercise. The challenges involved in evaluating progress toward sustainability include linking the indicators under the various criteria to make an overall assessment and defining benchmarks for future conditions. The development and use of C&I as an assessment tool is a progressive learning process that requires adjustments to be made as new information becomes available and existing knowledge is expanded. This process involves transparent reporting and timely sharing of information and mutual learning experiences among all stakeholders and interest groups.

Through the compilation of information for this report and the production of the 1997 capacity report, it has become apparent that the key data and information holdings, covering a variety of data types and formats, are dispersed throughout federal, provincial, territorial and municipal agencies and institutions and that C&I reporting could be greatly improved with the establishment of some key national initiatives. Foremost among these is a national mechanism to compile and provide timely and coordinated access to accurate forest information. Fostering collaboration between the various data gatherers, information custodians and user groups is critical to improving the nation's ability to report on the sustainability of its natural resources. A national, plot-based inventory, describing all classes of ownership, allowing for spatial and temporal measurements and trend estimates and including dedicated monitoring of insects and diseases, biodiversity, pollutants and non-timber resources would compliment such an information system and enhance the nation's capacity to assess the sustainability of its forests.

Because forest ecosystems are complex and highly variable, forest management and policy decisions will always be accompanied by uncertainty and risk. Our understanding of forest ecosystems and our capacity to predict and set benchmarks for future performance will be improved when ecosystem level models, such as the carbon budget model are developed to integrate information to predict the impact of changes on the sustainability of Canada's forests. Science will play an important role in the validation and interpretation of information for the development of adaptive management options and in the development of new techniques to measure indicators. For example, remote sensing is currently being tested for monitoring and reporting on 25 of the indicators in the CCFM framework. The initiatives of the CCFM working groups that are addressing sustainable forest management are described in Appendix 1. Appendix 2 highlights some of the projects being developed by the partners of the *National Forest Strategy* to design new methods, models, systems and tools to enhance the capacity to measure and report on the indicators and should significantly contribute to the advancement of C&I implementation in Canada.

The CCFM C & I framework has been in place since 1995. Recognizing that sustainable forest management is an adaptive process and that assessing sustainability is a continuous activity, the CCFM approved a review of the 83 indicators in the framework. This review will improve the relevance and efficiency of the indicators for reporting on and assessing progress toward sustainable development.

APPENDIX I Description of the initiatives of CCFM Working Groups that address sustainable forest management

Working Group	Description
National Forest Information System	Responsible for the preparation of a business plan for the development of a system to integrate data on all aspects of Canada's forests.
Canadian Criteria and Indicators	Responsible for the development and periodic evaluation of the CCFM framework of criteria and indicators of sustainable forest management, for reporting on the indicators and for establishing links to international and sub-national C&I processes.
National Forestry Database Program	Responsible for establishing a comprehensive national database on forest management activities in Canada and developing a public information program based upon the national database to provide timely and credible information to the policy process.
Canadian Forest Inventory	Responsible for observing, studying and discussing the continuing state, practice and research in Canada of forest inventory, inventory update, and other forest management statistics and to make recommendations regarding operational procedures; measurement standards; terminology; and, data acquisition, handling and reporting.
Science and Technology	Responsible for reviewing S&T data as a component of strategic agendas; developing S&T recommendations on forestry issues, and priorities and opportunities in the forest sector; and identifying new S&T opportunities for cooperation and coordination.
Forests 2020	Responsible for developing a strategy to ensure Canada's forest industries remain competitive while safeguarding the social and environmental value of Canadian forests.
International Forestry Partnerships Program	Responsible for communicating Canada's sustainable forest management policies and practices to key decision makers and influences in Europe, United States and Japan, securing a reasonable trade framework through the promotion of Canadian sustainable forestry initiatives and ensuring that trade barriers are not erected in export markets.
International Forest Convention	Responsible for preparing Canada's position on a range of legally and non-legally binding approaches for strengthening the international forest regime.
Canadian Interagency Forest Fire Centre	Responsible for facilitating interagency cooperation in wildland fire management, a cooperative venture that comprises federal, provincial and territorial wildland fire management agencies.
Aboriginal Forestry	Aboriginal participation and development of business partnerships and potential joint initiatives.
Private Woodlot Taxation	Responsible for reviewing taxation policies related to private woodlots to determine their impact on sustainable management practices and, if appropriate, recommending ways these tax policies could be improved to encourage sustainable forest management.
Canadian Forestry Communicators	Responsible for meeting the communication needs of the CCFM.

APPENDIX 2 Projects in response to National Forest Strategy (1998-2003) action plans that will contribute to the advancement of C&I implementation

Project	Description
1. National Forest Ecological Classification System for Canada.	A book and a CD-ROM will be produced describing a national ecological classification system that eliminates redundancies in regional systems. The system will be used for standardized reporting, for industrial applications and as a basis for the development of a national strategy for forest ecosystem management.
2. Management strategies to mimic the role of disturbance in maintaining forest ecosystem integrity.	Disturbances such as fire, insects, disease, and harvesting will be studied to determine their impact on forest ecosystems. Where possible, models will be developed to analyze adaptive management response strategies.
3. Network of protected areas representative of Canada's forest ecosystem classification categories.	A report on the network of protected areas representative of Canada's forest ecosystem classification categories will be produced.
4. Tools to analyze the impact of management options on multiple forest values.	Using case studies from *Armillaria* and spruce budworm, costs and benefits of management options will be determined. Non-timber valuation will be examined in a case study on recreation in Foothills Model Forest.
5. Predictive models to examine the impact of climate change on forest ecosystems.	National climate surfaces databases will be generated and used to design models to simulate effects on climate and climate variability on forest ecosystems.
6. Review of the national framework of criteria and indicators of sustainable forest management.	The Centre for International Forestry Research (CIFOR) field tested the CCFM indicators in Boise, Idaho in 1998. Incorporating the results of this test, a science-policy team will review the framework with respect to continued relevance and practicality for measuring sustainable forest management. Indicators will be refined as necessary.
7. Forest Steward[illegible]cognition Program.	Through the identification of examples of leadership and innovation in forest stewardship and forest biodiversity conservation, both public awareness and on-the-ground forest biodiversity conservation will be encouraged.
8. The inherent value to Canadians of the social and economic dimensions of forests.	Community dependence on the forest sector will be studied to identify social indicators of community sustainability and improve understanding as to how Canadians value social and economic forest values.
9. Forest sector science and technology tracking and reporting system.	A system to compile and track private and public forest sector S&T will be established. The system will provide information on level and allocation of Canada's forest sector and comparisons with other Canadian sectors and competing nations.

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GLOSSARY

ABIOTIC
Pertaining to the non-living component of the environment (e.g., climate, ice, soil and water).

ABUNDANCE
The number of organisms in a population, combining density within inhabited areas with number and size of inhabited areas.

ACIDIC DEPOSITION
The process by which acids are deposited, either as wet deposition in the form of rain, snow, sleet, hail, or fog; or as dry deposition in the form of particulates such as fly ash, sulphates, nitrates; or as gases like sulphur dioxide and nitric oxide. Dry particles and gases, deposited onto or adsorbed into surfaces, can be converted into acids after deposition or adsorption when they come in contact with water.

ADVANCE REGENERATION
Young trees under existing stands. Regeneration established before logging that has survived the logging operation.

AGE CLASS
A category into which the average age or age range of trees or other vegetation is classified. Age class is usually used in reference to even-aged stands of trees. It represents the dominant age of the main body of trees in a stand. In mixed-aged stands, age class can be used to describe the average age of specific cohorts of trees.

ALIEN SPECIES
Any species not native to a particular ecosystem.

AMBIENT
The quality of physical parameters in the surrounding, external, or unconfined conditions (e.g., air temperature or air pollution).

BEQUEST VALUE
The external benefit that accrues to individuals through the assurance that future generations will also have access to forests.

BIOFUEL
Fuels made from cellulosic biomass resources. Biofuels include ethanol, biodiesel and methanol.

BIOGEOCHEMICAL CYCLES
The cycling of elements such as carbon, nitrogen, oxygen, hydrogen, calcium, sodium, sulphur or phosphorus, between the abiotic and biotic components of the environment, including the atmosphere, terrestrial, aquatic and vegetative systems, through the processes of production, assimilation and decomposition.

BIOLOGICAL PRODUCTIVITY
The capacity to produce biomass; the production of biomass.

BIOMASS
The mass of organic matter per unit of area or volume of habitat.

BIOSPHERE
That part of the planet that supports life; consisting of the hydrosphere, the lithosphere, and the lower atmosphere.

BIOTA
All of the living organisms in a given ecosystem, including microorganisms, plants and animals.

BIOTIC
Pertaining to any living aspect of the environment, especially population or community characteristics.

BUFFER ZONE
A strip of land maintained along a stream, lake, road, recreation site or different vegetative zone to mitigate the impacts of actions on adjacent lands, to enhance aesthetic values, or as a best management practice.

CATALYST
A substance that changes the speed or yield of a chemical reaction without being consumed or chemically changed by it.

CHLOROFLUOROCARBONS (CFCs)
Industrial synthetic chemicals used in air conditioning, foam and cleaning solvents. CFCs can damage the ozone layer.

CLEARCUTTING
A silvicultural system in which the entire stand of trees is cleared from an area at one time. Clearcutting results in the establishment of a new even-aged stand of trees and can be implemented in blocks, strips or patches.

COARSE WOODY DEBRIS
Typically, sound or rotting logs, stumps, or large branches that have fallen or been cut and left in the woods, or trees and branches that have died but remain standing or leaning.

COMPACTION
A reduction in soil volume leading to poor soil aeration, reduced drainage and root deformation.

CONIFER
A wide range of tree species within the order Gymnospermae, typically evergreen, bearing cones, and having needle-shaped or scalelike leaves. Conifer timber is termed softwood.

CONNECTEDNESS
The structural links between habitat patches in a landscape.

CONVENTION ON BIOLOGICAL DIVERSITY
A global agreement to address all aspects of biological diversity: genetic resources, species, and ecosystems. The objectives are "the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources."

COSEWIC
An acronym for the Committee on the Status of Endangered Wildlife in Canada. COSEWIC lists and designates plants and animals in Canada according to their relative abundance at the national level.

COVER TYPE
See Forest Type.

CRITICAL LOAD
The highest deposition of acidifying (or other pollutants) compounds that will not cause chemical changes leading to long-term harmful effects on the overall structure or function of an ecosystem.

CROWN
The part of a tree or woody plant bearing live branches and foliage.

CROWN TRANSPARENCY
The amount of skylight visible through the foliated portion of a tree crown.

CUTOVER
An area of forest from which some or all of the timber has recently been cut.

DECIDUOUS
Trees typically belonging to the order Angiospermae with broad leaves that are usually shed annually.

DECOMPOSITION
The breakdown or decay of organic materials by the action of bacteria, fungi and other microorganisms.

DEFOLIATION
An unseasonable reduction in the foliage cover of a plant due to attacks by insects or fungal disease, or as a result of other factors such as drought, storms, or chemicals in the atmosphere.

DISTURBANCE
A significant change in the structure and/or composition of ecosystems, communities or populations through natural or human-induced events.

ECOCLIMATIC REGIONS
Ecologically based regions in which the plant succession and rate of growth are similar on similar sites.

ECOSYSTEM
A dynamic system of plants, animals and other organisms, together with the non- living components of the environment, functioning as an interdependent unit.

ECOSYSTEM-BASED MANAGEMENT
Management systems that attempt to simulate ecological processes with the goal of maintaining a satisfactory level of diversity in natural landscapes and their pattern of distribution in order to ensure the sustainability of forest ecosystem processes.

ECOZONE
A broad-scale ecological unit that is based on patterns that include climate, geography and ecological diversity. A framework of 15 ecozones, subdivided into 53 ecoprovinces, 194 ecoregions and 1 020 ecodistricts is the national ecological classification of Canada.

ENVIRONMENTAL SERVICE VALUE
Values related to the ability of forest ecosystems to assimilate waste and respond to human disturbances while continuing to provide environmental goods and services, such as clean air and water, soil retention and wildlife habitat.

EROSION
The wearing away of the land surface by running water, wind, ice, or gravity.

EXISTENCE VALUE
The external benefit that accrues to individuals, having no intention of ever visiting or using the site or environment in question, simply through knowledge that the area, feature, or goods exist in a particular condition.

EXTINCTION
The termination of a species caused by failure to reproduce and death of all the remaining members of that species.

EXTIRPATION
The elimination of a species or subspecies from a particular area, but not from its entire range.

EVEN-AGED
Of a forest stand, or forest type in which relatively small age differences (usually less than 10 to 20 years) exist between individual trees.

FAUNA
The animal community found in one or more regions.

FIRE ACTIVITY
Ignition, flame development, spread and intensity of a forest or wildland fire.

FIRE LOAD
In Canada, the number and magnitude of all fires requiring suppression action during a given period within a specified area.

FIRE MANAGEMENT
The activities concerned with the protection of people, property, and forest areas from wildfire and the use of prescribed burning for the attainment of forest management and other land-use objectives, all conducted in a manner that considers environmental, social, and economic factors.

FIRE REGIME
The characteristic frequency, extent, intensity, severity, and seasonality of fires within an ecosystem.

FIRE SUPPRESSION
All activities concerned with controlling and extinguishing a fire following its detection.

FLORA
The plant species found in one or more regions, or eras.

FOREST-DEPENDENT COMMUNITY
A community that relies on the forest sector for more than 50% of its economic base.

FOREST TYPE
A group of forested areas or stands of similar composition that can be differentiated from other such groups. Forest types are usually separated and identified by species composition and often also by height and crown closure classes.

FULL SUPPRESSION FIRE
A forest or wildland fire that is controlled as quickly as is reasonably possible.

GAP ANALYSIS
An analytical technique in which the extent of existing protected areas is overlaid with maps of species and ecosystem distribution to identify gaps in the protective network.

GEOGRAPHIC INFORMATION SYSTEM (GIS)
An information system that uses a spatial database to provide answers to queries of a geographical nature through a variety of manipulations, such as sorting, selective retrieval, calculation, spatial analysis and modelling.

GLOBAL WARMING
A projected increase in atmospheric temperatures caused by release into the atmosphere of the gaseous by-products (principally carbon dioxide) of fossil-fuel consumption, which trap long-wavelength radiant energy.

GREENHOUSE GAS
Molecules in the Earth's atmosphere such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and chlorofluorocarbons (CFCs), which warm the atmosphere because they absorb some of the thermal radiation from the surface of the Earth.

GREENHOUSE GAS SINKS
Any process, activity or mechanism that removes greenhouse gases or their precursors from the atmosphere at a greater rate than they release them. The principal natural mechanism is photosynthesis.

GREENHOUSE GAS SOURCE
Any process or activity (e.g., forest fires or conversion of forest land to agricultural or urban uses) that releases greenhouse gases or precursors of those gases into the atmosphere at a greater rate than they remove them. As trees and forest products decompose or burn, they release carbon in the form of carbon dioxide.

HARDWOOD
Typically refers to the wood of broad-leaved trees, most of which are Angiosperms and deciduous.

HABITAT GENERALIST
Any species capable of exploiting a broad range of habitats or niches.

HERITAGE LEGISLATION
Legislation addressing the protection of sites that have cultural, historical or spiritual significance for present and future generations.

HUMUS
A brown or black complex material resulting from the partial decomposition of plant or animal matter and forming the organic portion of the soil.

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE
A panel, open to all members of the United Nations Environment Programme and the World Meteorological Organization. The IPCC assesses the scientific, technical and socio-economic information relevant to the understanding of the risk of human-induced climate change.

INVASIVE SPECIES
Any species not native to a particular ecosystem whose introduction does or is likely to cause economic or environmental harm or harm to human health.

JOULE
Unit of energy and work. (A petajoule is 10^{15} joules).

KYOTO PROTOCOL
Binding targets for reduction in greenhouse gas emissions were agreed to for the first time by major industrial nations meeting at the United Nations Climate Change Conference in Kyoto in December 1997.

LANDSCAPE
A spatial mosaic of several ecosystems, landforms and plant communities intermediate between an organism's normal home-range, size and its regional distribution.

MICROORGANISM
An organism too small to be seen with the unaided eye (e.g., a virus, bacterium, protozoan, yeast cell, fungal hypha).

MIXEDWOOD
Stands of trees having a well-mixed composition of angiosperms (hardwoods) and gymnosperms (softwoods).

MODIFIED FIRE RESPONSE
Response to a forest or wildland fire at less than full suppression; normally employed in low-value areas.

MUTUAL LEARNING
A rational and reasonable exchange of information in the spirit of partnership.

MYCORRHIZA
The symbiotic association between higher plant roots and specific fungi that aid plants in the uptake of water and certain nutrients.

NATIVE SPECIES
A species known to have existed on a site prior to the influence of humans.

NITROUS OXIDE
Nitrous oxide (N_2O) is a minor greenhouse gas released when chemical fertilizer is used and fossil fuels are burned. It occurs naturally in the environment; however, in recent years, quantities have increased because of human activities.

NON-MARKET CONSUMPTIVE GOODS
Products (e.g., berries, mushrooms, craft products, firewood, fiddleheads, Christmas and ornamental trees) that individuals harvest from forest lands free of charge.

NUTRIENT CYCLE
The exchange of elements among living and nonliving components of an ecosystem.

OPTION VALUE
The amount an individual would be willing to pay (or would have to be paid to agree to sell) to preserve the option to participate in some activity or to use some resource at some future time, whether or not that individual ever actually participates or uses the resource.

OZONE
A form of oxygen (O_3) formed naturally in the upper atmosphere by a photochemical reaction with solar ultraviolet radiation. When formed at ground level, it becomes a major agent in the formation of smog.

PARTICULATE
Of or relating to minute separate particles.

PHOTOSYNTHESIS
The process by which plants transform carbon dioxide and water into carbohydrates and other compounds, using solar energy captured by chlorophyll in the plant. Oxygen is a byproduct of the process.

PHYTOTOXIC
Poisonous to plants.

PPM
Parts per million. One million equals one thousand thousand.

PRESERVATION VALUE
The external benefit derived from existence, option and/or bequest values.

REFORESTATION
The natural or artificial restocking of an area with forest trees.

REMOTE SENSING
The science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object and that uses wavelengths from the ultraviolet to radio regions of the spectrum.

RENEWABLE RESOURCE
A natural resource that is capable of regeneration.

RESILIENCE
The capacity of a community or ecosystem to maintain or regain the desired condition of diversity, integrity and ecological processes following disturbance.

RESPIRATION
The physical and chemical processes by which an organism provides its cells and tissues with the oxygen needed for metabolism and relieves them of the carbon dioxide formed in energy-producing reactions.

RIPARIAN ZONE
A strip of land of variable width adjacent to and influenced by a body of fresh water.

RUN OFF
That portion of the precipitation on a drainage area that is discharged from the area in stream channels.

SAVANNAH
A major global biome consisting of open grasslands containing scattered trees or shrubs.

SCARIFICATION
A method of seedbed preparation which consists of removing the forest floor or mechanically mixing it with the mineral soil to eliminate or reduce the dead organic material.

SELECTION CUTTING
Also called partial cutting. An uneven-aged silvicultural system in which trees are removed individually or in small groups continuously at relatively short intervals, resulting in a constant renewal of a forest crop.

SERAL STAGES
Also called successional stages. The series of plant community conditions that develop during ecological succession from bare ground (or major disturbances) to the climax stage.

SERAL SPECIES
Plant species of early, middle, and late successional plant communities. The term is often used in a narrower sense in forest management to describe the dominant conifer vegetation that follows major disturbance episodes.

SHELTERWOOD CUTTING
A silvicultural system used in even-aged stands in which groups of trees are harvested in a design that uses adjacent or overhead large trees for seed or to protect regeneration.

SILTATION
The filling-in of lakes and stream channels with soil particles, usually as a result of erosion on adjacent land.

SILVICULTURE
The theory and practice of controlling the establishment, composition, growth and quality of forest stands; can include basic silviculture (planting and seeding) and intensive silviculture (site rehabilitation, spacing and fertilization).

SMOG
Air pollution typically associated with oxidants.

SOFTWOOD
The timber of coniferous trees.

STRUCTURE
The distribution of trees in a stand or group by age, size or crown class.

SUCCESSION
Changes in the species composition of an ecosystem over time, often in a predictable order.

TENURE
The act of owning, using or controlling land or the resources of that land under certain terms and conditions.

TROPOSPHERE
The lower layer of the Earth's atmosphere stretching from the ground to the upper atmosphere (stratosphere).

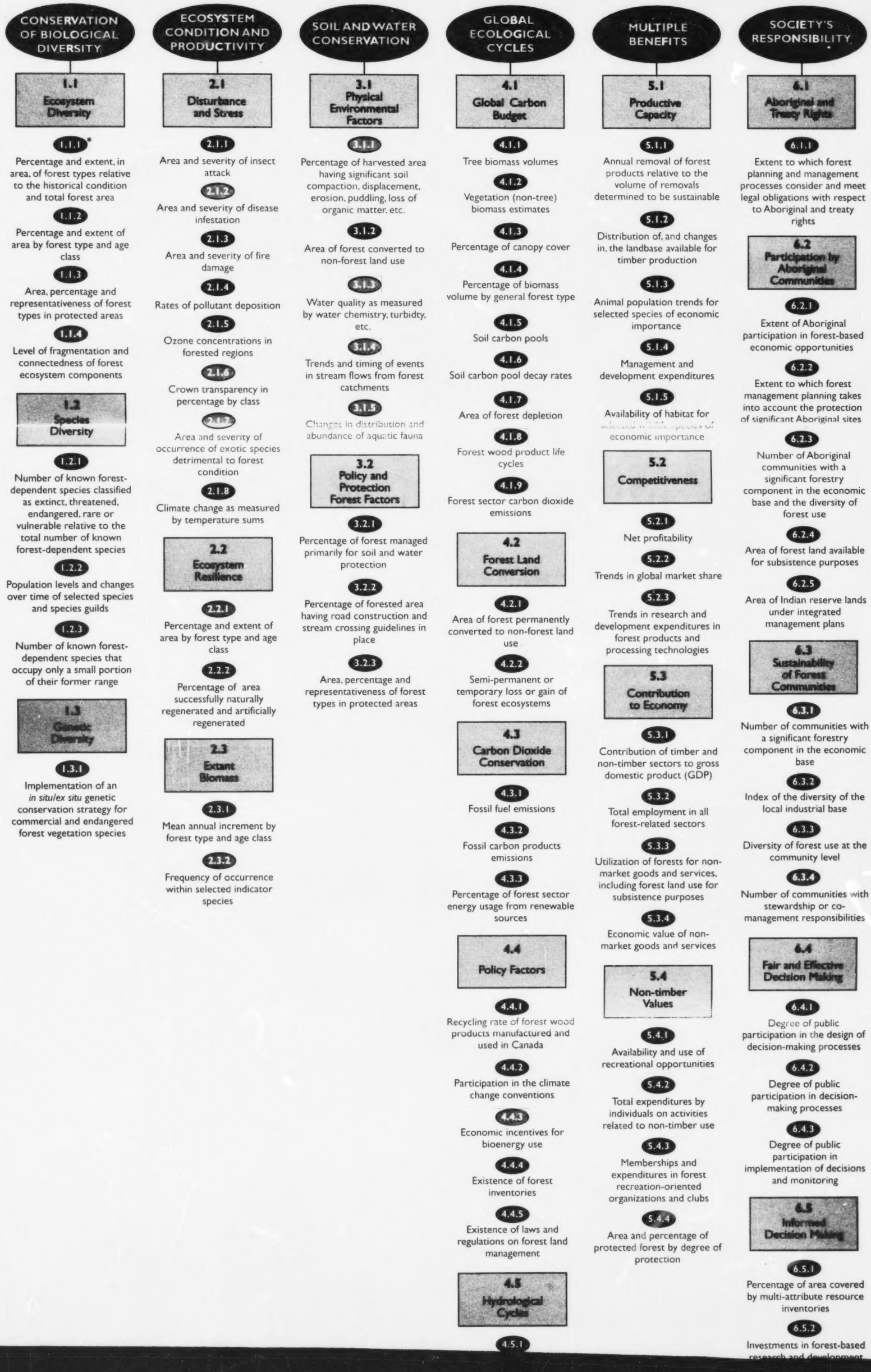
TURBIDITY
A measure of water clarity, or the degree to which water is rendered opaque by the suspended silt or other sediments.

UNEVEN-AGED
Of a forest, stand, or forest type in which the intermingled trees differ in age by more than 10 to 20 years.

VALUE-ADDED PRODUCTION
Manufacturing that adds value to a primary product as it passes through various processing stages.

VARIABLE-RETENTION SILVICULTURAL SYSTEM
Harvesting method by which some forest cover is retained.

Natural Resources Canada
Ressources naturelles Canada
Canadian Forest Service
Service canadien des forêts
Terrestrial Ecozones of Canada
Arctic Ocean
Arctic Cordillera
Northern Arctic
Southern Arctic
Taiga Cordillera
Taiga Plains
Taiga Shield
Boreal Cordillera
Boreal Plains
Boreal Shield
Pacific Maritime
Montane Cordillera
Prairies
Hudson Plains
Mixedwood Plains
Atlantic Maritime
Pacific Ocean
Nunavut
Hudson Bay
Alberta
Saskatchewan
Manitoba
Ontario
Quebec
Labrador and Newfoundland
Prince Edward Island
Nova Scotia
New Brunswick
Atlantic Ocean
0 250 500 km
Source: Ecological Stratification Working Group, 1995


CONSERVATION OF BIOLOGICAL DIVERSITY
1.1 Ecosystem Diversity
1.1.1* Percentage and extent, in area, of forest types relative to the historical condition and total forest area
1.1.2 Percentage and extent of area by forest type and age class
1.1.3 Area, percentage and representativeness of forest types in protected areas
1.1.4 Level of fragmentation and connectedness of forest ecosystem components
1.2 Species Diversity
1.2.1 Number of known forest-dependent species classified as extinct, threatened, endangered, rare or vulnerable relative to the total number of known forest-dependent species
1.2.2 Population levels and changes over time of selected species and species guilds
1.2.3 Number of known forest-dependent species that occupy only a small portion of their former range
1.3 Genetic Diversity
1.3.1 Implementation of an *in situ/ex situ* genetic conservation strategy for commercial and endangered forest vegetation species
ECOSYSTEM CONDITION AND PRODUCTIVITY
2.1 Disturbance and Stress
2.1.1 Area and severity of insect attack
2.1.2 Area and severity of disease infestation
2.1.3 Area and severity of fire damage
2.1.4 Rates of pollutant deposition
2.1.5 Ozone concentrations in forested regions
2.1.6 Crown transparency in percentage by class
2.1.7 Area and severity of occurrence of exotic species detrimental to forest condition
2.1.8 Climate change as measured by temperature sums
2.2 Ecosystem Resilience
2.2.1 Percentage and extent of area by forest type and age class
2.2.2 Percentage of area successfully naturally regenerated and artificially regenerated
2.3 Extant Biomass
2.3.1 Mean annual increment by forest type and age class
2.3.2 Frequency of occurrence within selected indicator species
SOIL AND WATER CONSERVATION
3.1 Physical Environmental Factors
3.1.1 Percentage of harvested area having significant soil compaction, displacement, erosion, puddling, loss of organic matter, etc.
3.1.2 Area of forest converted to non-forest land use
3.1.3 Water quality as measured by water chemistry, turbidty, etc.
3.1.4 Trends and timing of events in stream flows from forest catchments
3.1.5 Changes in distribution and abundance of aquatic fauna
3.2 Policy and Protection Forest Factors
3.2.1 Percentage of forest managed primarily for soil and water protection
3.2.2 Percentage of forested area having road construction and stream crossing guidelines in place
3.2.3 Area, percentage and representativeness of forest types in protected areas
GLOBAL ECOLOGICAL CYCLES
4.1 Global Carbon Budget
4.1.1 Tree biomass volumes
4.1.2 Vegetation (non-tree) biomass estimates
4.1.3 Percentage of canopy cover
4.1.4 Percentage of biomass volume by general forest type
4.1.5 Soil carbon pools
4.1.6 Soil carbon pool decay rates
4.1.7 Area of forest depletion
4.1.8 Forest wood product life cycles
4.1.9 Forest sector carbon dioxide emissions
4.2 Forest Land Conversion
4.2.1 Area of forest permanently converted to non-forest land use
4.2.2 Semi-permanent or temporary loss or gain of forest ecosystems
4.3 Carbon Dioxide Conservation
4.3.1 Fossil fuel emissions
4.3.2 Fossil carbon products emissions
4.3.3 Percentage of forest sector energy usage from renewable sources
4.4 Policy Factors
4.4.1 Recycling rate of forest wood products manufactured and used in Canada
4.4.2 Participation in the climate change conventions
4.4.3 Economic incentives for bioenergy use
4.4.4 Existence of forest inventories
4.4.5 Existence of laws and regulations on forest land management
4.5 Hydrological Cycles
4.5.1
MULTIPLE BENEFITS
5.1 Productive Capacity
5.1.1 Annual removal of forest products relative to the volume of removals determined to be sustainable
5.1.2 Distribution of, and changes in, the landbase available for timber production
5.1.3 Animal population trends for selected species of economic importance
5.1.4 Management and development expenditures
5.1.5 Availability of habitat for selected wildlife species of economic importance
5.2 Competitiveness
5.2.1 Net profitability
5.2.2 Trends in global market share
5.2.3 Trends in research and development expenditures in forest products and processing technologies
5.3 Contribution to Economy
5.3.1 Contribution of timber and non-timber sectors to gross domestic product (GDP)
5.3.2 Total employment in all forest-related sectors
5.3.3 Utilization of forests for non-market goods and services, including forest land use for subsistence purposes
5.3.4 Economic value of non-market goods and services
5.4 Non-timber Values
5.4.1 Availability and use of recreational opportunities
5.4.2 Total expenditures by individuals on activities related to non-timber use
5.4.3 Memberships and expenditures in forest recreation-oriented organizations and clubs
5.4.4 Area and percentage of protected forest by degree of protection
SOCIETY'S RESPONSIBILITY
6.1 Aboriginal and Treaty Rights
6.1.1 Extent to which forest planning and management processes consider and meet legal obligations with respect to Aboriginal and treaty rights
6.2 Participation by Aboriginal Communities
6.2.1 Extent of Aboriginal participation in forest-based economic opportunities
6.2.2 Extent to which forest management planning takes into account the protection of significant Aboriginal sites
6.2.3 Number of Aboriginal communities with a significant forestry component in the economic base and the diversity of forest use
6.2.4 Area of forest land available for subsistence purposes
6.2.5 Area of Indian reserve lands under integrated management plans
6.3 Sustainability of Forest Communities
6.3.1 Number of communities with a significant forestry component in the economic base
6.3.2 Index of the diversity of the local industrial base
6.3.3 Diversity of forest use at the community level
6.3.4 Number of communities with stewardship or co-management responsibilities
6.4 Fair and Effective Decision Making
6.4.1 Degree of public participation in the design of decision-making processes
6.4.2 Degree of public participation in decision-making processes
6.4.3 Degree of public participation in implementation of decisions and monitoring
6.5 Informed Decision Making
6.5.1 Percentage of area covered by multi-attribute resource inventories
6.5.2 Investments in forest-based research and development

Policy Factors

4.4.1
Recycling rate of forest wood products manufactured and used in Canada

4.4.2
Participation in the climate change conventions

4.4.3
Economic incentives for bioenergy use

4.4.4
Existence of forest inventories

4.4.5
Existence of laws and regulations on forest land management

4.5 Hydrological Cycles

4.5.1
Surface area of water within forested areas

5.4 Non-timber Values

[illegible]
Availability of [illegible] recreational opportunities

5.4.2
Total expenditures by individuals on activities related to non-timber use

5.4.3
Memberships and expenditures in forest recreation-oriented organizations and clubs

5.4.4
Area and percentage of protected forest by degree of protection

Fair and Effective Decision Making

6.4.1
Degree of public [illegible]ion in the design of [illegible]n-making processes

6.4.2
Degree of public participation in decision-making processes

6.4.3
Degree of public participation in implementation of decisions and monitoring

6.5 Informed Decision Making

6.5.1
Percentage of area covered by multi-attribute resource inventories

6.5.2
Investments in forest-based research and development information

6.5.3
Total effective expenditures on public forestry education

6.5.4
Percent of forest area under management, including public participation

6.5.5
Expenditure on international forestry

6.5.6
Mutual learning mechanisms and processes

*Highlighted indicators represent those reported in the *National Status 2000*.

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